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SURVEYING AND MAPPING

Editor-in-Chief
Howard S. Rappleye,

A QUARTERLY JOURNAL
DEVOTED TO THE ADVANCEMENT OF THE SCIENCES
OF SURVEYING AND MAPPING

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October–December 1956

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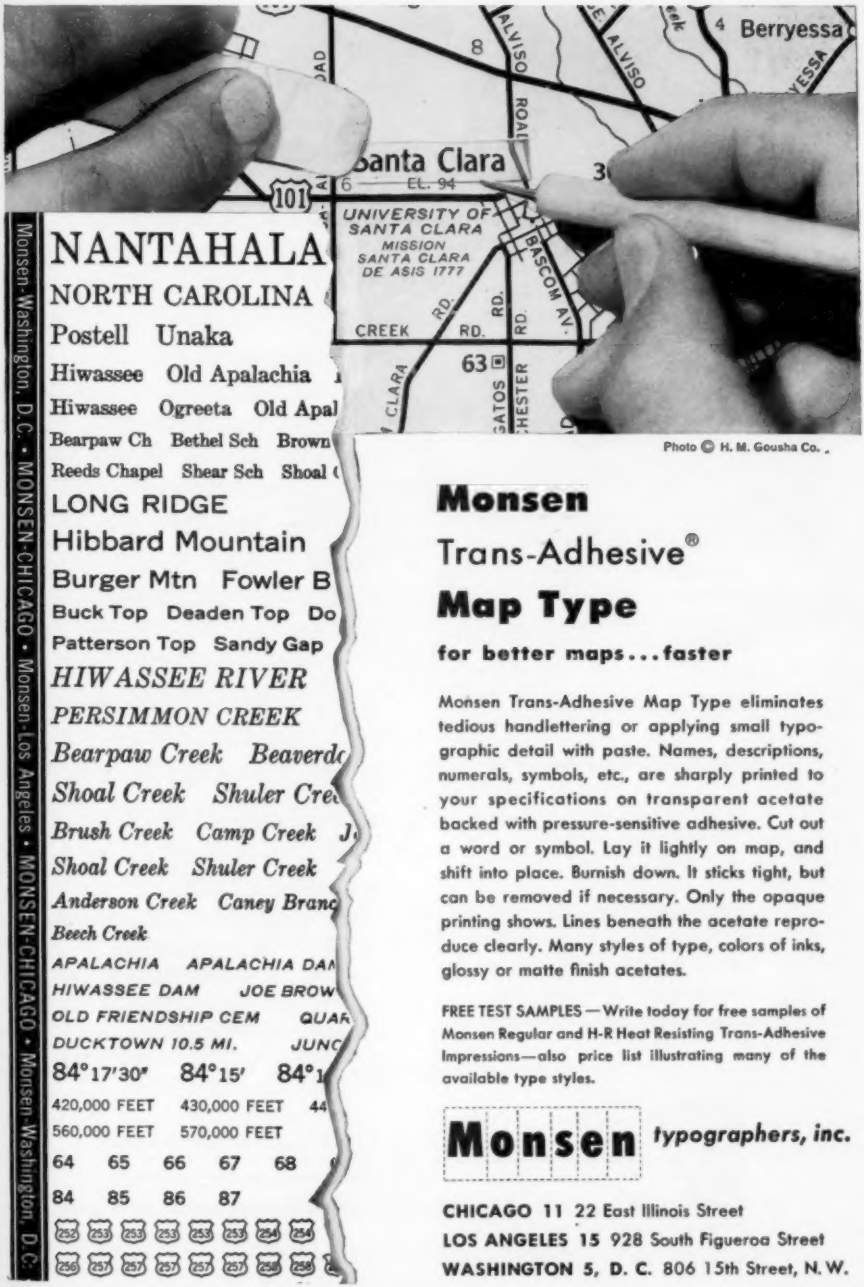

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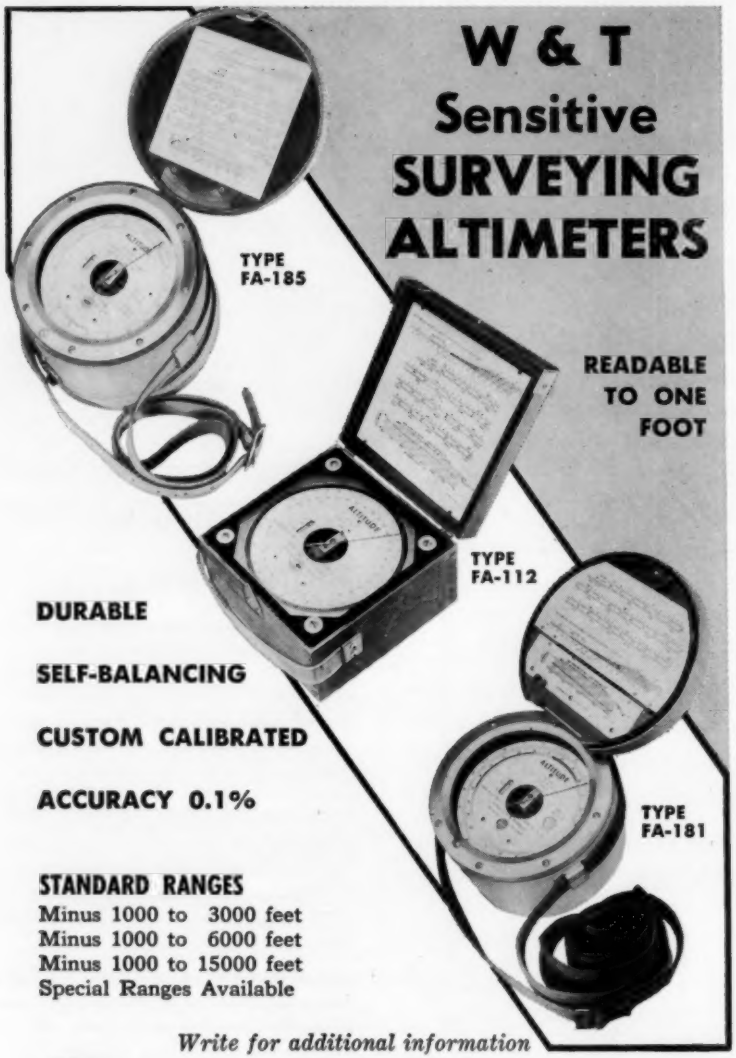

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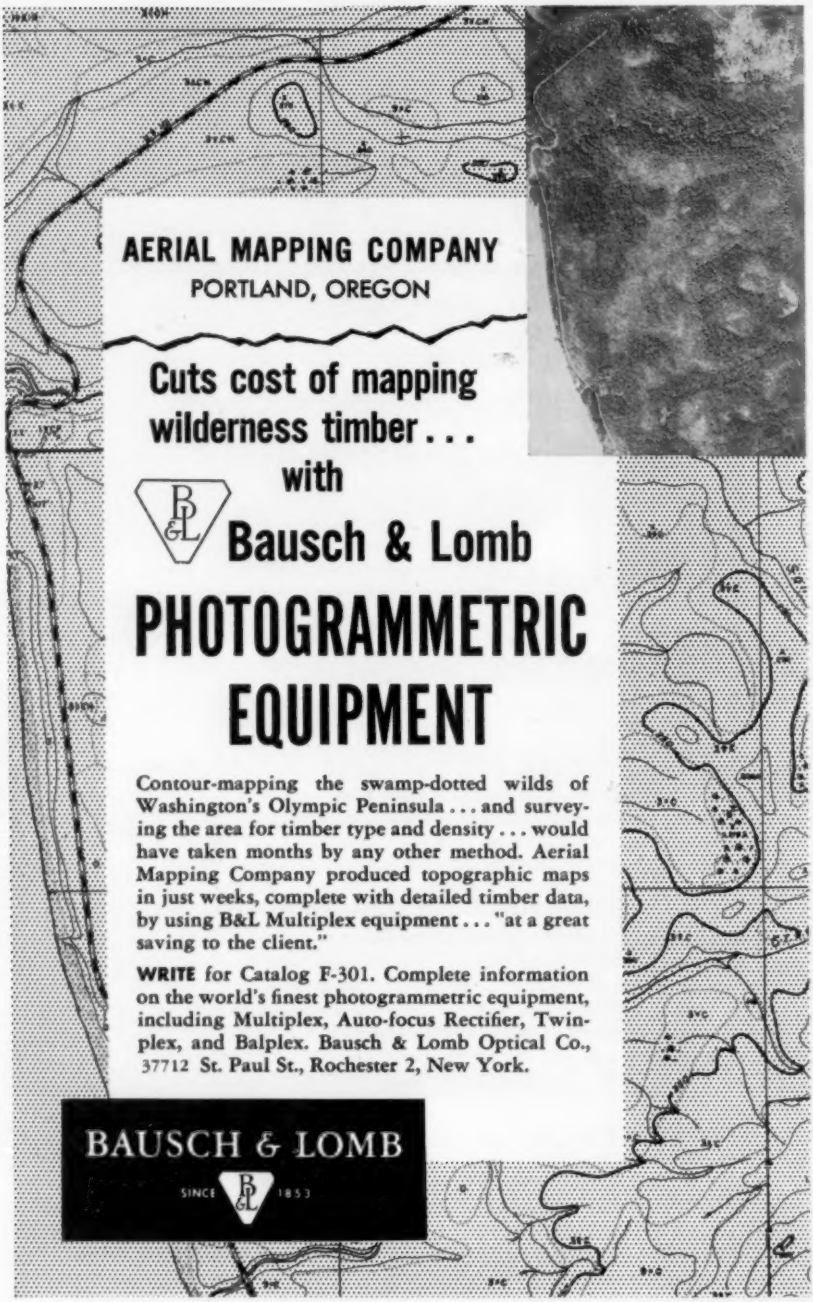

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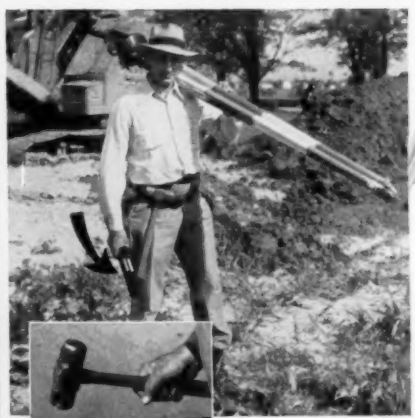

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World Mapping

By REAR ADMIRAL H. ARNOLD KARO
DIRECTOR, COAST AND GEODETIC SURVEY

THE ULTIMATE mapping goal of the leading nations of the world is to have this globe of ours completely covered with accurate, detailed maps—maps which clearly define every coastal outline, and every river, lake, and mountain—maps with every city and town and all other cultural features properly located. Integrally associated with the delineation of physical and cultural detail is the accurate determination of distance and direction.

As man progressed from a nomadic existence to tribal and community living the need for better and more detailed maps developed. Stabilized residence, property ownership, and progressive industrialization created ever-expanding requirements for precise and detailed mapping. Through the ages mapping techniques have marched steadily along in step with advancing civilization. In addition to being an indispensable adjunct in assisting man in coping with his environment, maps have stimulated new fields of research and have provided a useful medium in furthering man's quest of the unknown.

Mapmaking did not originate as a science, or even as an art, but evolved slowly and haltingly from obscure origins. The ancient concept of maps or geography was closely related to mythology, as illustrated by the belief that certain islands of the Aegean Sea were not fixed in permanent locations. This early concept of floating islands has become a partial reality in the floating ice islands of the Arctic.

Maps are not only a factor in promoting world progress but are also an index of progress achieved. History reveals the part played by mapping among empire-building nations of the world.

The rise of sovereign states created the need for the systematic preparation of more detailed and accurate maps. Such maps were primarily for military purposes and to meet the needs of expanding commerce. These requirements, therefore, were not confined to sovereign territory but covered adjacent areas—sometimes for extensive distances. In addition to being indispensable as a defensive measure, mapping was essential for offensive purposes. This factor was mainly responsible for 17th- and 18th-century maps being primarily military in character.

The full usefulness of maps for civil purposes was not immediately apparent. Even today it is doubtful if more than a small percentage of the peoples of the world understand or appreciate the value of accurate and detailed maps.

During the past decade we have become used to having maps and charts available in almost every conceivable size, shape, or form. For this reason it is hard for us to visualize that less than a quarter of the earth's surface can be considered adequately mapped.

Proper evaluation of maps is a job for an expert. The average layman is unable to evaluate accurately the artistically drawn and handsomely colored maps with which modern lithography provides us.

World War II demonstrated in a most realistic manner the lack of good world-wide map coverage. This deficiency was not confined entirely to the backward and undeveloped areas of the globe. For instance, accurately-drawn detailed maps of the channel coast of France were nonexistent when the need arose. The urgent need of maps to meet a war emergency on a global basis resulted in greatly accelerated mapping activities both at home and abroad. This expanded need has continued not only for direct military operations and planning but also for the location of strategic materials, political considerations, and world-wide commercial undertakings.

Presented at the Sixteenth Annual Meeting of the American Congress on Surveying and Mapping, Washington, D. C., March 19–21, 1956.

Since it serves the common good, mapping must be recognized as an essential public service—therefore, a function of government. This important undertaking calls for complete coordination by governments within their own boundaries and, due to the complexities of modern civilization, geopolitics, and other considerations, it calls for ever-increasing international coordination. This does not mean, however, that special mapping to meet particular needs should not be undertaken by private enterprise. The point I am making is that government has a clear duty to *undertake* or *direct* all basic mapping which can provide the necessary details needed by all interests for proper development and administration. Such detailed mapping provides for a general and up-to-date picture without which planning degenerates into confusion and frustration.

The leading nations of the world must, of course, give first consideration to complete, detailed, and accurate coverage of their entire nation domain. National mapping programs in turn contribute to world mapping which is a composite of the mapping that each country carries on unilaterally as a matter of national policy.

Modern existence itself must depend upon a host of maps and charts vital to planning global economy and defense. The development of natural resources and the unprecedented industrial expansion of modern times are dependent in large measure upon adequate maps. Almost any basic endeavor you would care to name, can be better planned, and better executed, if accurate detailed maps are available.

Generally speaking, long-established, thickly populated, and highly developed countries are the best mapped. Centuries of property disputes have resulted in the mapping of most European countries, and the British Isles, to the highest degree of refinement.

The progressive economic expansion of the United States, as well as the peaceful development and expansion of all nations, makes necessary a critical appraisal of existing map data, in order that adequate plans can be developed to meet present and future contingencies. A detailed inventory is needed to uncover major deficiencies in map coverage. Planning can then proceed on a sound basis to overcome these deficiencies.

The production of maps is entirely dependent, of course, upon adequate survey data. Systematic governmental surveys date from about 1750 when Cassini, under orders from Louis XV, began work on his great map of France at the scale of about 1:84,000. Since that time all leading nations have engaged in extensive national programs of surveying and mapping.

Modern mapping is a complicated process due to the earth's spherical shape. Principles must be applied to surveying which take into account the curvature of the earth, otherwise discrepancies would result in measurements. Actually, the earth is neither flat nor exactly spherical, but approximates a sphere flattened slightly at the poles. This problem in spherical geodesy is a complicated factor in world mapping.

Thus, the first requirement of large-scale mapping or charting is the establishment of accurate, rigid, geodetic control to insure proper coordination and maximum usefulness. Precise horizontal and vertical control insures that every feature and detail appearing on maps and charts will be shown in its true position.

Basic control obtained by *geodetic surveys* includes triangulation, baseline measurements, traverse, leveling, and astronomic and gravity determinations in which the figure and size of the earth are taken into account. Geodesy provides the methods and techniques essential to precision mapping on a world-wide basis.

Sufficient triangulation data had become available shortly after the beginning of the 19th century to afford a modern determination of the figure and size of the earth. Geodesists have been very active since that time in determining the mean figure of the earth. New values were derived progressively in direct relationship with the steady advancement in scientific findings. The value of the equatorial radius has tended to increase since about 1800, with the amount of increase being in the order of two kilometers.

In 1858 the noted British geodesist, A. R.

Clarke, made his first determination which is quite close to the best current opinion, both as to the equatorial radius and the flattening. Since that time progressive refinements have been made and a well-established continental datum now is accurate to within one or two seconds of arc, or between 100 or 200 feet. The equatorial diameter of the earth is known to within probably 300 feet; the general trend of the reciprocal of the flattening, which we now put at 297 ± 1, has decreased progressively. With these refinements in dimensions, it is possible to compute global distances with considerable accuracy. For instance, a distance determination between a selected point in the United States and another point in Europe is believed to be possible with an accuracy of 1000 feet or probably less.

Latitude and longitude of a point on the earth's surface can be directly determined only by astronomic observations. Also a well-established datum depends on astronomic observations for many latitude and longitude stations, connected by triangulation. One astronomic station cannot be depended upon alone due to the fact that the vertical on which the observations depend may deviate considerably from the normal to the spheroid on which the triangulation is computed. Final results are obtained by an averaging process whereby the results of many astronomic observations are taken into account.

Simply stated, latitude at any given point is equal to the angle of elevation of the celestial pole, or that point which marks the center of the circles transcribed by the stars in their daily apparent travel. Actually, much more refined methods are employed, but the principle is the same. Longitude is determined by observing the universal time of the stars as they cross the local meridian.

The force of gravity is also an important factor to be considered in determining astronomic position. All astronomic observations depend upon the direction of gravity which must be defined by very accurate spirit levels. Although the observations are well referenced to the direction of gravity, they must also be referenced to the perpendicular or normal to the spheroid on which the triangulation is computed. This factor involves the geoid which closely approximates an ellipsoid of revolution which is a mathematical surface on which triangulation can be computed.

It is possible with proper gravity coverage to establish a triangulation datum with a single astronomic observation for latitude and longitude. Good gravity coverage provides data for correcting the deflection of the vertical. Many gravity observations, adequately controlled horizontally and vertically, are required over an area as large as two or three hundred miles to afford the necessary gravity coverage for this method.

The geoid can be visualized as the earth covered by oceans with no islands or continents; however, the geoid is not quite a smooth surface since it has "humps and hollows." Relatively speaking, the earth is probably smoother and more nearly a sphere than most bowling balls. Nonetheless, the direction of gravity is always perpendicular to the geoidal surface and this can differ as much as one minute of arc, or as much as a mile on the ground, from the normal to the spheroid.

In any engineering or scientific undertaking involving large continental areas, it is important that full coordination and correlation be secured of the surveys upon which the maps and charts of the country are based. We know that a hydrographic or topographic feature on the earth can have but one latitude and one longitude. These must be the same on every map or chart on which it appears. This can be accomplished through the adoption of a single horizontal datum for the triangulation points in the country.

It is apparent that the geoid cannot be used as a reference for computing survey data, even if its exact shape were known. This led to the development of a geometrical surface that approximates as closely as possible the true geoidal surface. The mathematically computed spheroid is, therefore, the first step in establishing a geodetic control system. This search for an accurate figure of the earth is not peculiar to any one country; scientists throughout

the world have contributed their part to solving this basic problem.

Electronics may be said to be the key to modern world mapping. The development of electronic methods of distance determination has opened the way for effective intracontinental adjustments and correct relationships between continents and off-lying islands. As a result of the development of electronic measurement techniques during World War II, the whole field of surveying and mapping—on land, at sea, and in the air—is undergoing radical changes. The surveyor, whether he be geodetic, topographic, or hydrographic, has discovered a new yardstick for extending his work. This new concept is based on the velocity of propagation of radio and light waves. Instruments using that yardstick have been or are being designed to reduce the cost of surveys and, even more important, to accomplish surveys heretofore impossible with conventional methods.

The geodetic surveying phase of world mapping is followed by the production of the basic series of topographic maps of a country. The geodetic networks provide the framework for measuring and depicting on maps the physical features of a given area, whether it is by quadrangle or maps of a country, state, national, or continental area. Topographic maps include both the planimetry and relief representing physical characteristics of the terrain and may be at any scale, depending upon the use to be made of them.

Maps prepared from original surveys by national or state governments for use in scientific, engineering, and military operations are usually published at comparatively large scales, varying from 1:20,000 to one inch to the mile, or less. Intensively developed and thickly populated countries, especially those on the European continent, utilize larger scales for their original map series in contrast with substantially smaller scales over most of the remainder of the globe.

Topographic maps portraying the physiography of the earth's surface serve as base maps from which all others are largely derived. The poorest mapped areas are found in the interior of the world's great land masses. Most of the interior of Africa, Asia, Australia, Arabia, Greenland, the polar regions, and vast expanses in South America are completely lacking in large-scale map coverage.

Military considerations now provide the greatest single impetus to map making; by the same token, military classifications and restrictions are the greatest impediment to world-wide exchanges of mapping data.

Surveying and mapping techniques are being constantly improved to meet the unprecedented demands for more and better maps. Instead of climbing mountains with heavy equipment strapped to his back, the modern surveyor can now set down gently with helicopters. Heretofore inaccessible areas can in like manner be reached by airlift. We are now using the geodimeter which utilizes the speed of light in measuring baselines in a fraction of the time formerly required.

Topographic mapping by photogrammetric methods has largely replaced the slower and more laborious planetable and traverse methods. Stereoplotting and other photogrammetric techniques, including new related processes for transferring aerial photographs onto map manuscripts suitable for reproduction, are being progressively perfected with greatly improved accuracy.

The United States in recent years has assumed important international leadership in advancing the science of surveying and mapping. Private organizations, such as the National Geographic Society and the American Geographical Society and the various technical societies have made valuable contributions toward a better-mapped world.

Coastal areas of the world are far better mapped, in general, than inland areas. The reason for this is the important part that the nautical chart has played in the commerce and industrial development of maritime countries. The nautical chart is basic to water-borne commerce; it is just as important to the ship as the compass, the radio, or the rudder. Without adequate charts, free and unrestricted intercourse by water would be impossible.

In furtherance of world commerce the great maritime powers have given the necessary support to surveying and charting all navigable waters that must be used by the ships of all nations. These activities are coordinated through the International Hydrographic Bureau which has its principal headquarters in Monaco. This international agency has supported publication of the general Bathymetric chart of the oceans. This global series of 24 charts systematically presents in convenient form the wealth of oceanic data obtained by navigators, oceanographers, geographers, geologists, and others.

The Arctic, Antarctic, South Pacific, and South Atlantic Ocean areas are the most deficient in information. Due to the vastness of the ocean areas relatively few areas can be considered adequately covered. Some information must of necessity remain unpublished for security reasons.

Figure 1 presents a graphic appraisal of world-wide topography in five categories of reliability. Major deficiencies are revealed at a glance by the extensive blank areas. The most reliable coverage is indicated in black and includes large-scale mapping at one inch to the mile or larger. Other shadings indicate secondary large-scale coverage at one inch to two miles, inferior large-scale coverage; secondary medium-scale coverage, and map coverage at 1:500,000 or smaller. The unshaded areas are almost wholly unmapped with any degree or reliability. This appraisal shows that not more than 25 percent of the land area of the world is covered with even reconnaissance type topographic maps at a scale of 1:250,000 or larger that have been compiled from the aerial photography or systematic ground surveys. I must therefore take exception to Mr. Peattie's article in the March 1956 *Readers Digest* in which it was stated that "about half of the world's area has been mapped accurately."

The appraisal shows further that only about 5 percent of the land surface of the earth can be considered as having large-scale topographic maps based on adequate geodetic control. Approximately 8 to 10 percent of the land area of the earth is covered with secondary large-scale topographic maps. About 5 percent has inferior large-scale coverage lacking in adequate geodetic control. This category applies particularly to China. Large areas are covered with secondary medium-scale mapping, such as compiled from trimetrogon photography. The remainder of the coverage indicated in the appraisal, as category 5, is useful mainly for reference purposes and for planning more detailed mapping projects.

Figure 2 is a graphic appraisal of world-wide nautical chart coverage, also classified in five categories. The first and most reliable coverage, indicated by black dots, is at the scale of 1:50,000 or larger. The other classifications indicate coverage at scales varying from 1:50,000 to 1:100,000, at 1:100,000 to 1:600,000, and smaller than 1:600,000. Track lines are symbolized by crosshatching.

When we consider that about 70 percent of the surface of the earth is covered by water, reliable world-wide nautical chart coverage seems extremely deficient. As in other forms of mapping the concentration of reliable nautical chart coverage is along shores of the more highly developed maritime nations, their territories, colonies and dependencies.

Modern nautical charting is virtually nonexistent over most of the open ocean areas. These areas are being covered with track-line soundings which give general information. Many nations are now exerting intensive effort in surveying and charting territorial waters. Nautical charting is costly and progress is slow except when there is immediate economic necessity or in times of national emergency. The International Hydrographic Bureau is making significant strides in stimulating interest in charting the oceans of the world. The foreign charting programs of the United States Navy Hydrographic Office and the British Admiralty make significant contributions to world nautical charting.

Figure 3 emphasizes the close relationship existing between worldwide aeronautical chart coverage and topographic maps of the earth. In appraising the status of aeronautical chart coverage, adequacy and reliabil-

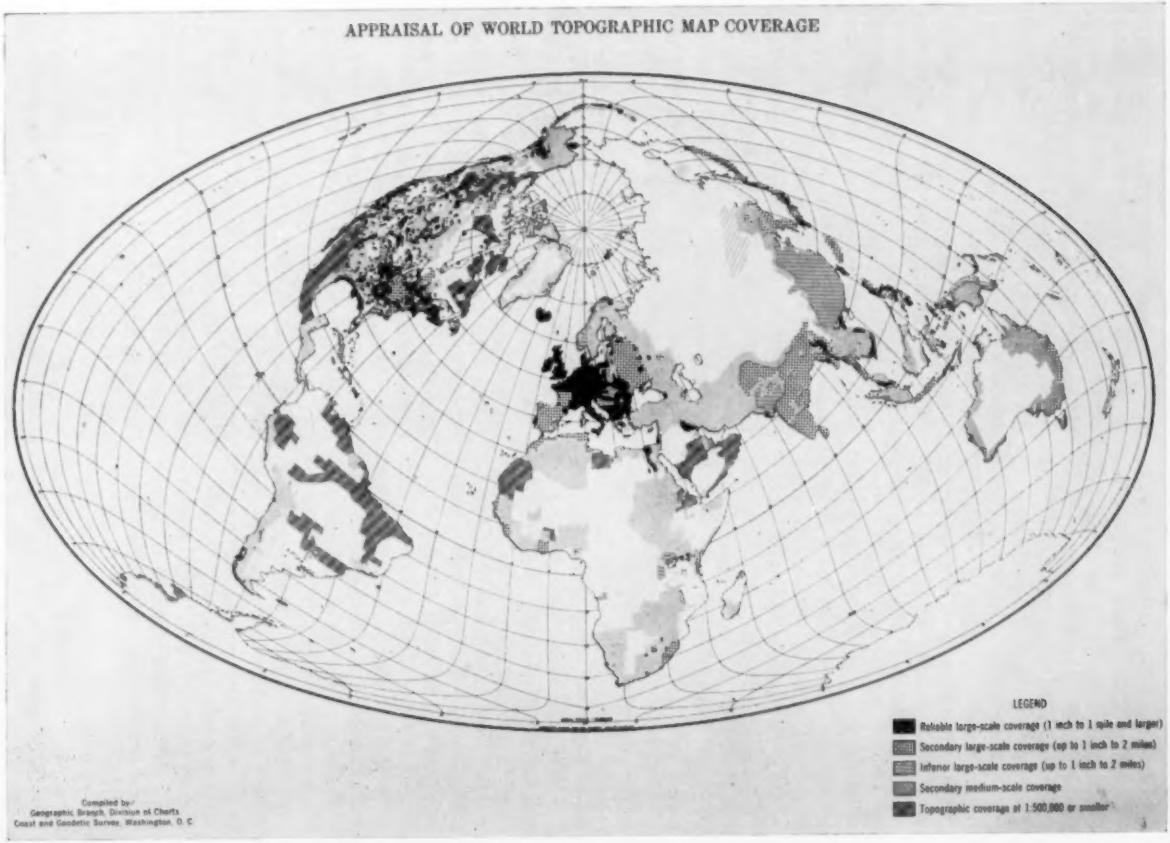
APPRAISAL OF WORLD TOPOGRAPHIC MAP COVERAGE
LEGEND
Reliable large-scale coverage (1 inch to 1 mile and larger)
Secondary large-scale coverage (up to 1 inch to 2 miles)
Inferior large-scale coverage (up to 1 inch to 2 miles)
Secondary medium-scale coverage
Topographic coverage at 1:500,000 or smaller
Compiled by
Geographic Branch, Division of Charts
Coast and Geodetic Survey, Washington, D. C.

FIGURE 1.—Appraisal of world topographic map coverage.

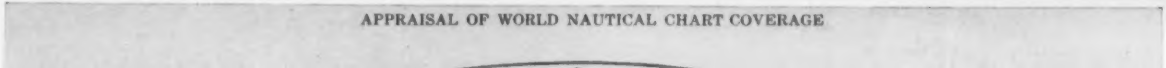

FIGURE 1.—Appraisal of world topographic map coverage.

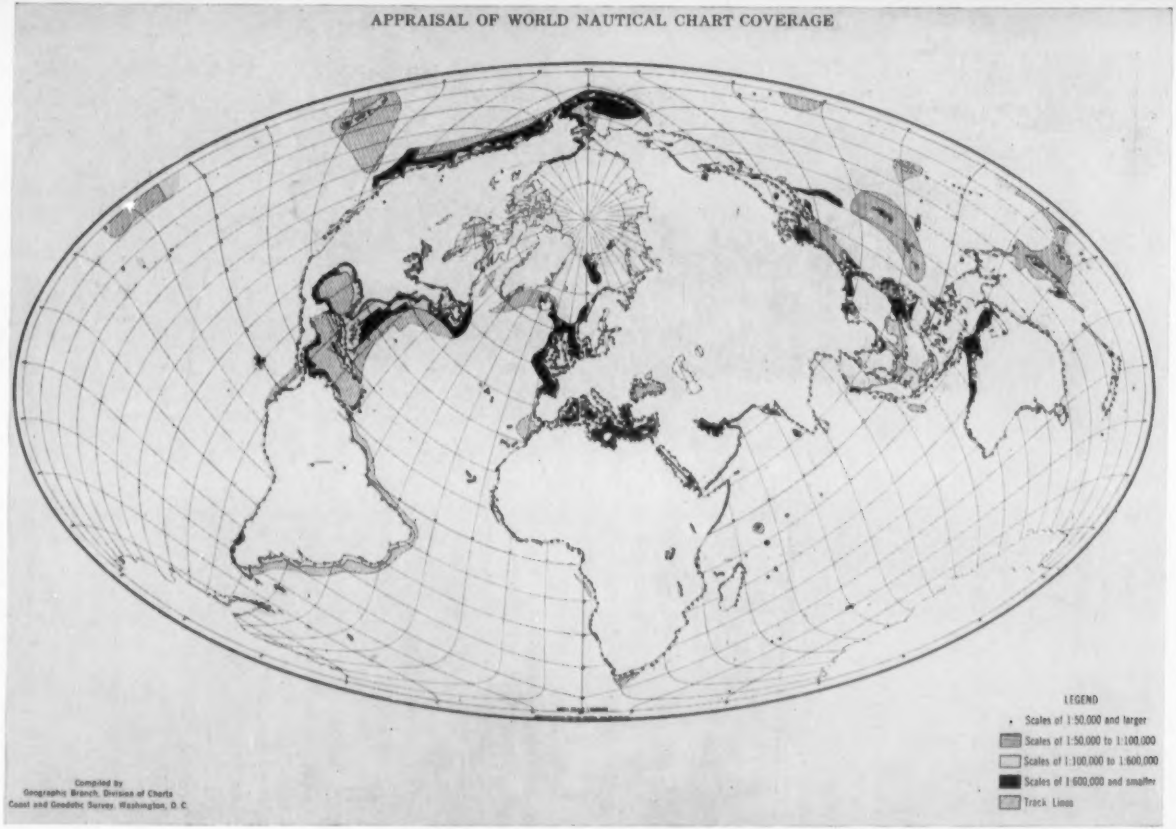
APPRAISAL OF WORLD NAUTICAL CHART COVERAGE
LEGEND
Scales of 1:50,000 and larger
Scales of 1:50,000 to 1:100,000
Scales of 1:100,000 to 1:600,000
Scales of 1:600,000 and smaller
Track Lines
Compiled by
Geographic Branch, Division of Charts
Coast and Geodetic Survey, Washington, D. C.

FIGURE 2.—Appraisal of world nautical chart coverage.

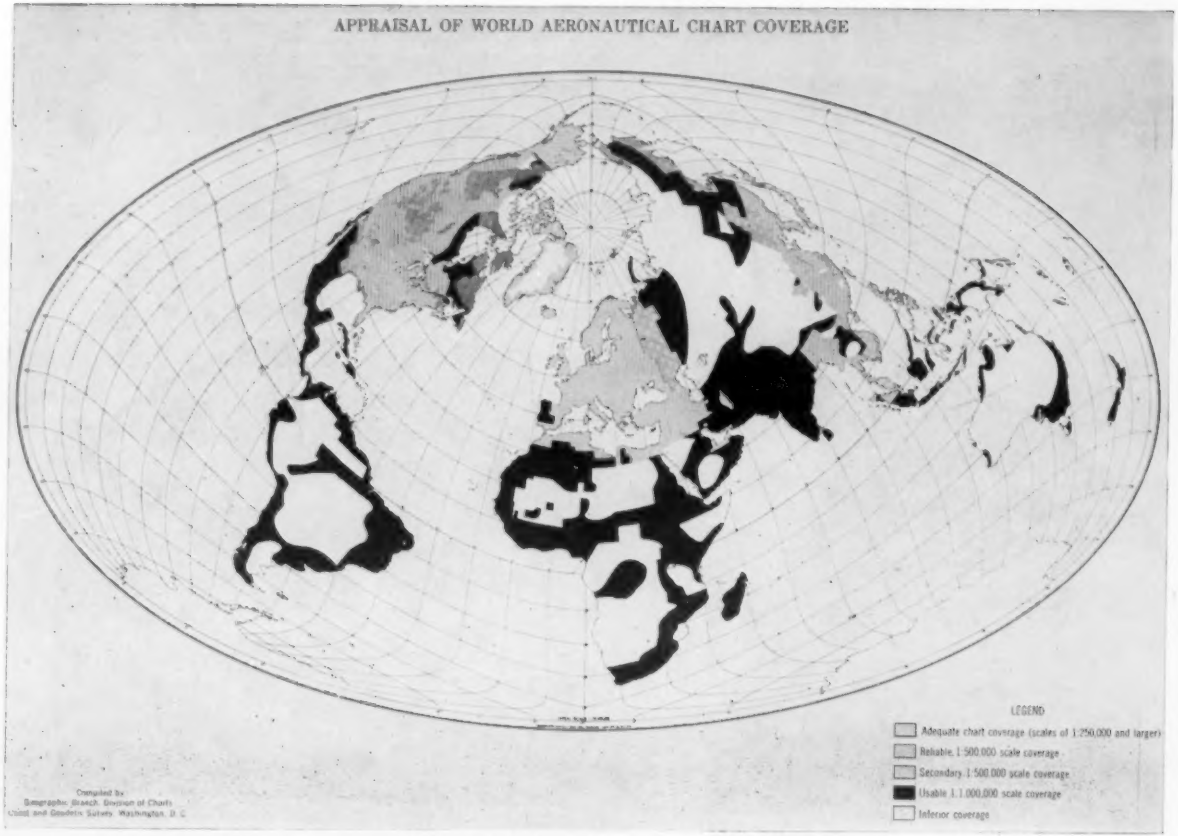
APPRAISAL OF WORLD AERONAUTICAL CHART COVERAGE
LEGEND
Adequate chart coverage (scales of 1:250,000 and larger)
Reliable, 1:500,000 scale coverage
Secondary, 1:500,000 scale coverage
Usable 1:1,000,000 scale coverage
Inferior coverage
Compiled by
Geographic Branch, Division of Charts
Coast and Geodetic Survey, Washington, D. C.

FIGURE 3.—Appraisal of world aeronautical chart coverage.

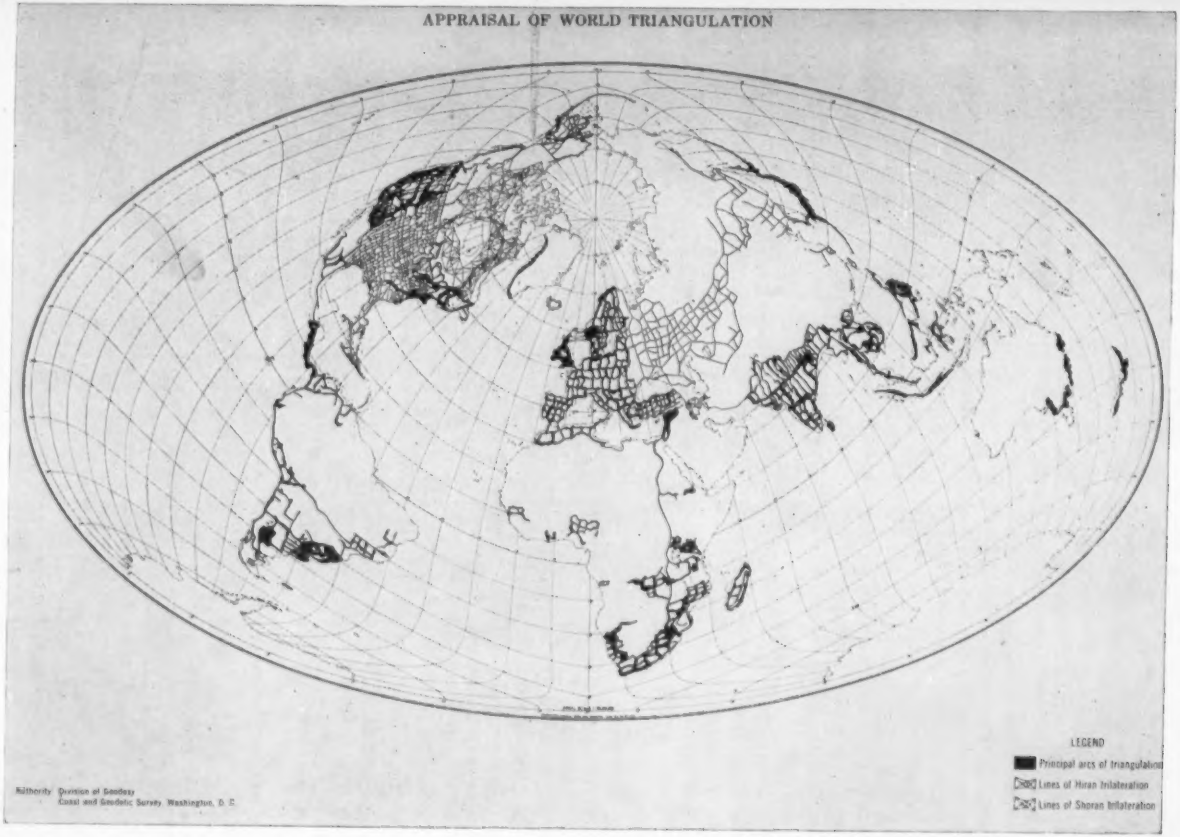
APPRAISAL OF WORLD TRIANGULATION
LEGEND
Principal arcs of triangulation
Lines of Hiran trilateration
Lines of Shoran trilateration
Authority Division of Geodesy
Coast and Geodetic Survey, Washington, D. C.

FIGURE 4.—Appraisal of world triangulation.

ity were evaluated more in terms of safety and utility rather than in terms of absolute minute accuracy of geodetic control.

The first category, shown in a gray line, indicates adequate chart coverage up to scales of 1:250,000; other shadings of gray show reliable 1:500,000-scale coverage; and secondary 1:500,000-scale coverage; black shows usable coverage at 1:1,000,000 scale. The unshaded areas are classified as inferior.

Figure 4 shows the location of world geodetic control nets considered capable of meeting present-day criteria for control surveys. This presentation is mainly schematic. No attempt has been made to show secondary breakdowns within the control networks nor to depict numerous detached local control schemes.

The major deficiencies are apparent in the northern half of South America except for a band along the west coast; most of Africa, except for the southern and southeastern part, a narrow band along the Mediterranean, and the 30th meridian arc; most of the Near East; China; Asiatic Russia and Siberia north of latitude 56° north; and most of Australia.

It may be noted that no geodetic tie exists between the Western Hemisphere and Europe, Africa, or Asia. It will be geographically simple to make such a tie across Bering Strait from Alaska to Siberia. A program is underway to connect the geodetic datums of Europe and North America by means of electronic trilateration between Great Britain, Iceland, Greenland, and Canada.

The job that lies ahead is vast indeed, but the effort and cost are small compared to the great benefits that will be derived from having adequate maps of the globe upon which we must live. Political boundaries are being transcended in carrying on greatly expanded mapping projects in various areas lacking in map coverage. Technical experts are being sent from the United States to other countries where mapping is urgently needed for economic development and administration of social services.

During the past decade young engineers and scientists from numerous foreign countries have been trained by the Federal mapping agencies in Washington. In addition to most of the Latin American countries, Burma, Egypt, Ethiopia, Turkey, Pakistan, Thailand, Korea, India, Indonesia, Iran, Italy, the Philippines, and Spain are among the nations that have sent trainees to the United States. Important contributions to mapping in their respective countries are now being made by many of these trainees since returning to their native lands.

Wall Map of Detroit

A new wall-size map of Detroit, Mich., and vicinity is the Geological Survey's latest addition to its series of topographic maps covering important metropolitan areas throughout the Nation.

Cultural and physical data contained on portions of fourteen 7½-minute quadrangles of Greater Detroit have been compiled as two sheets, each measuring approximately four feet north and south by six feet east and west. The compilation is from 1:24,000-scale maps of the Mt. Clemens West, Warren, Birmingham, Pontiac South, Redford, Royal Oak, Highland Park, Grosse Pointe, Belle Isle, Detroit, Dearborn, Inkster, Detroit-Wayne Airport, and Wyandotte quadrangles. The individual maps were originally prepared in 1951 from aerial and ground surveys.

All railroad lines entering the city are shown, also freight marshalling yards, several lakes, reservoirs, parks, principal ship channels in the Detroit River, airports, tunnels, roads and highways. The main portion of the city is tinted in red to indicate areas in which only landmark buildings are shown individually.

Hydrography along the Detroit River was compiled from U. S. Lake Survey charts. Canadian topography was accomplished in cooperation with the Canadian Department of Defense from the Canadian Windsor and Belle River quadrangles.

The composite map has been printed in five colors at a scale of 1:24,000. Copies are $3.00 per set of two sheets, available from the Geological Survey, Washington 25, D. C. Orders originating west of the Mississippi River should be addressed to Survey offices, Federal Center, Denver, Colo.

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Control Surveys In Canada

By J. E. R. ROSS

DOMINION GEODESIST

THE VAST AREA of Canada, slightly larger than the United States, imposes a variety of problems upon the surveyor, not only by virtue of size, but also by virtue of climactic conditions and smallness of population, largely distributed near the International Boundary along a narrow belt averaging less than 200 miles in depth, in which are confined the transportation facilities of railways and highways. To the north of the St. Lawrence River, the Great Lakes, and the agricultural sections of the Prairies, lies the major area, which lacks highways and roads, and except for the main rivers is devoid of any means of rapid surface transportation. This area has now been made accessible everywhere by the aeroplane, which in turn has stimulated the search for mineral wealth with results of great economic importance. World-wide conditions have also focussed attention upon defense matters. The requirements for economic development and defense have emphasized the need for a vast improvement in the scale, accuracy, and detail of new maps to replace those hitherto available. This in turn means an analysis of the available control upon which the new maps must be based.

CONTROL OF MINOR ACCURACY

The organizations which have been, and still are, engaged in control surveys of a sufficient standard of accuracy, are mostly Federal, although the Survey Department of British Columbia has projected triangulation surveys in the mountainous interior, which have been correlated as a unit through geodetic attachment.

International Boundary Survey.—The International Boundary is controlled almost entirely by minor triangulation, although precise traverse has been used for relatively short sections, and all of this has been connected with the geodetic framework, thus providing consistent data in position and elevation. Along the 141st-meridian section of the Canada-Alaska boundary, geodetic ties have been made at four stations with the Alaska triangulation.

Local Survey and Aeronautical Charts.—The Block and Township surveys, extended from reference meridians and base lines of the Dominion Lands Surveys system in the three prairie provinces (Manitoba, Saskatchewan, and Alberta), constitute an important local control for mapping purposes, as linear measurements are made to an accuracy of about 1:10,000 and courses are astronomically observed. In the period 1871–1930, during which the control of the resources and public lands remained under Dominion authority, there were surveyed 281,250 square miles, an area 2.3 times as large as the British Isles and slightly greater than that of Texas (265,896 square miles). Most of this survey lies in the settled areas immediately north of the International Boundary.

Since 1930 some of the reference meridians have been projected northward to and beyond latitude 60° into the Northwest Territories, and upon these further base lines and township outlines have been extended to new areas of settlement.

In recent years, the 60th parallel of latitude, which forms the northern boundary of the four provinces west of Hudson Bay, has been projected and monumented eastward 1000 miles to within 350 miles of Hudson Bay. The Manitoba-Ontario oblique boundary to Hudson Bay has also been surveyed. These surveys have been positioned astronomically by the Geodetic Survey and the line operation has been carried out under various provincial boundary commissions composed of provincial and Federal

Presented at the 16th Annual Meeting of the American Congress on Surveying and Mapping, March 19-21, 1956, Washington, D. C.

representatives. These afford a base-line control for other surveys in the near locality.

Radar altimetry is also a function of this organization. Many profiles have been recorded across northern sections of the country, and each season's work adds greatly to the elevation data. One difficulty is that of reference datums related to mean sea level, but this is gradually being overcome. The accuracy in elevation between datum lakes is assessed as of the order ± 10 feet.

Topographical Survey.—Where geodetic control is available, chains of quadrilaterals are extended into the area to be mapped. The accuracy aimed at is high and varies between 1:10,000 and 1:20,000, more care being taken with the longer arcs. An example of this type is the 800-mile loop, based on the Canada-Alaska boundary, easterly from Dawson, Y. T., to Norman; thence, down the Mackenzie River to north of the Arctic circle; and westerly to the boundary near Rampart House. Other chains are based on exploratory astronomic fixation and closed shoran stations.

Secondary mapping control consists of minor triangulation within the above mentioned chains, to provide a denser pattern of control points, which are accurately identified on the air photographs. In mountainous areas, this control is a combination of photo-topo and third-order triangulation and has been found particularly suitable for 1:250,000 mapping. In areas of low relief, the control is increased by additional triangles and intersection on the sides of the nets. In northern Quebec, triangulation has been extended as much as 50 miles east and west from the geodetic net to control 1:50,000 mapping.

In the past much reconnaissance mapping control was established by stadia between astro-fixes and most of the larger features have been so mapped. A large number of astro-fixes were observed, identified in air photos, and used as control for 8-mile maps and 1:250,000 reconnaissance maps. Adjustments are made and map positions are revised when the geodetic control or better quality mapping control reaches these areas of astro-fixes.

Vertical control in mountainous areas is supplied from vertical angles with systematic ties to good quality levels. Recently several long spirit level lines have been established in the Northwest Territories and northern Saskatchewan and Manitoba.

One line extends from Fort Providence at the outlet of Great Slave Lake down to tidewater at the mouth of the Mackenzie River. Another line links Great Slave Lake and Great Bear Lake and continues down Bear River to Mackenzie River at Fort Norman. A further level line out of Great Slave Lake extends from Fort Reliance to Baker Lake, and the closure on this loop is within 2 feet. In the winter of 1954–55 a 600-mile loop of levels was extended from Pelican Narrows to Reindeer Lake, Wollaston Lake, Black Lake, Cree Lake, and back to Ile a la Crosse. The closure in this loop was 2 feet. Last summer a spirit level line was extended from Black Lake to Aderdeen Lake on the Thelon River and from Baker Lake through Yathkyed Lake to Ferguson Lake. The purpose of these level lines is to provide reasonable control for future survey operations in these areas, and it is generally the intention to further break down the vast areas by other similar lines.

In the above type of level operation full advantage is taken of the water surfaces in lake systems. Lines of levels are usually run only between the lakes.

The Army Survey Establishment.—The principal functions of the mapping agency of the Department of National Defense are:

(*a*) Production of topographical maps for defense purposes and of special maps as required,
(*b*) Maintenance of a cadre of trained survey personnel and the operation of a base map reproduction unit in war,
(*c*) Training of survey tradesmen, and
(*d*) Map distribution to the Department of National Defense.

Field surveys are conducted to provide vertical and horizontal control. Surveys are carried out within the framework of geodetic control where it is available. Triangulation coupled with terrestrial photography (phototopography) is generally used in mountainous areas to provide both horizontal and vertical control. Areas of lesser relief are

generally controlled horizontally by transit-and-chain traverse and vertically by instrumental and barometric leveling. Precision of these surveys is to the order required for 1:50,000 mapping.

In recent years the helicopter has replaced the pack horse on most of the mountain parties, although economics still call for the use of the latter occasionally. Barometric leveling in the Northwest Territories is carried out entirely by helicopter.

Shoran controlled photography based on the shoran trilateration net established by the Geodetic Survey and the Royal Canadian Air Force throughout the Northwest Territories is used to provide horizontal control for 1:250,000 sheets in that area. So far, 34,000 lineal miles have been flown, which are now used to control an area of approximately 500,000 square miles. This work has been carried out under civilian contract.

CONTROL OF MAJOR ACCURACY

Obviously the answer to some of the individual problems of the above organizations is a survey organized to conduct control operations of major accuracy. This control should not be allowed to deteriorate to serve special interests, but should be maintained at such a level of accuracy as to serve all present and future needs in so far as they may be foreseen.

This is a recognized approach in most countries and results in a geodetic survey being established. Unfortunately, in the relatively undeveloped or sparsely populated countries, action is not taken soon enough, and when the demand arises major control is far behind the needs. In this respect Canada, by virtue of size, is an outstanding example.

Below are given the texts of two important documents of the Committee of the Privy Council (P.C. 766 and P.C. 630), approved by His Excellency the Governor General.

"On a Memorandum dated 5th April 1909, from the Minister of the Interior, submitting that during the last four years a triangulation has been in progress in the better settled parts of the Provinces of Ontario and Quebec, under the Astronomical Branch of the Department of the Interior, the object of which is to determine with the highest attainable accuracy the positions of points throughout the country, and the lengths and directions of lines which may form the basis of surveys for all purposes, topographical, engineering, or cadastral and thereby assist in the survey work carried on by other Departments of the Dominion Government, by the Provincial Governments and by municipalities, private persons, or corporations. The operations have also included a considerable length of lines of precise leveling:

"The expense of the work has been paid out of the appropriation for Astronomical Surveys, which among other objects, provides for 'the astronomical and geodetic work of the Department of the Interior.'

"The Minister recommends that since the operations so far carried on have shown that this accurate basis for surveys of all kinds can be provided for at reasonable cost, and since the value of such work is universally admitted, being vouched for by worldwide experience, that the work be continued under the designation of the Geodetic Survey of Canada*, and that Dr. W. F. King, the Chief Astronomer, be named Superintendent of the same.

"The Committee submit the same for approval."

(Approved 20 April, 1909)

"WHEREAS the Minister of the Interior reports that the Geodetic Service of the Department of the Interior has been carrying on precise levelling since 1906;

"That in 1931 the Department of Public Works transferred all original field books and records, resulting from precise level operations carried on by that Department since 1883, to the Geodetic Service of the Department of Interior;

"That since that time all precise leveling in Canada has been brought under one organization and has now been consolidated into one national system of levels referred to one datum plane;

"That a number of different datum planes have been, and still are, in use in Canada and that this condition tends to confusion;

"That mean sea level has been generally adopted by other countries as their datum plane for elevations and is the datum plane to which the national system of precise levels of the Geodetic Service of the Department of the Interior has been referred;

"THEREFORE His Excellency the Governor General in Council, on the recommendation of

* Now under Department of Mines and Technical Surveys.

the Minister of the Interior, is pleased to order and it is hereby ordered that mean set level, as determined at coastal points by the Canadian Hydrographic Service and extended inland by the Canadian Geodetic Service, shall be the official datum plane for elevations in Canada and shall be known as the Canadian Geodetic Datum;

"His Excellency in Council is further pleased to order that the elevations of all works or projects of the Government of the Dominion of Canada which may originate after the date hereof shall be referred to this datum, where possible."

(Approved 11 March, 1935)

The above Orders-in-Council furnish ample proof of the necessity of a geodetic survey in the coordination of surveys of lesser accuracy. They do not, however, convey the magnitude of the task in application to the size of Canada, nor indicate the number of personnel which might be required to advance the work, within a reasonable time, so as to be in a position to provide control for even the areas of settlement and expansion existing in 1909.

In the intervening years, the permanent staff of the Geodetic Survey of Canada has never exceeded 75 persons, inclusive of clerical help, and at no time have more than 19 parties been engaged in a field season. Because of the country's latitudinal extent, operations are mostly performed in the summer season.

The Geodetic Survey is organized in five sections, i.e., Triangulation, Precise Leveling, Astronomy (precise and exploratory), Shoran Trilateration, and Mathematical Adjustments. Remarks pertinent to these sections and to this paper are given below under separate headings.

Triangulation.—The basic framework is composed of first- and second-order arcs which in general follow the routes of transportation. These arcs are gradually being extended to form loops northward from the International Boundary.

The advantages of triangulation consist in the density of points which may be established in a narrow belt, and the numerous base lines thus supplied, from which minor triangulation may be extended sidewise to increase the density of control for other purposes.

Each party is now supplied with the vertical photos of the route through which the observing is progressing and identification of the station site on the photo is made during the occupation of a station. This has greatly increased the value of the triangulation for mapping purposes.

Occasionally it has been necessary to establish an astronomic datum for local triangulation conducted for a specific purpose. These schemes are gradually being connected with the main framework, and to date only one of these surveys remains isolated.

At present no chain of triangulation exists in Canada connecting the eastern and western portions. Operations are now being advanced to complete the link in northern Ontario.

All results are based on the North American 1927 datum thus maintaining the basic data on a continental basis.

A start has now been made on three arcs of first-order triangulation to extend the control north of the prairie provinces and in northern Quebec. These operations are to be supported by aeroplane.

It has been found to be more economical to measure base lines concurrently with the observation of angles, as the added manpower is available in the area and aircraft do not have to be rechartered.

The Survey has just purchased a geodimeter, and it is hoped to replace all tape measurements by geodimeter measurement. This instrument should permit an increased number of control lengths to be placed in the net, thereby contributing to increased accuracy.

Precise leveling in Canada was first undertaken by the Geodetic Survey in 1907. The work of that year was centered in the Province of Quebec, the initial bench mark being the U.S.C. & G.S. bench mark in the Chapman Block, Rouses Point, N. Y. As time progressed, the net was extended eastward and westward and at the year 1956 serves all provinces.

For many years the net was virtually com-

posed of two nets—Eastern Canada and Western Canada joined by a single line of levels extending from Port Arthur, Ont., to Winnipeg, Man. In late years, however, considerable precise work was done in this district and the intermediate link was strengthened so as to make a fairly uniform net in depth across the country.

At the present time, for adjustment purposes the level net is composed of 332 junction points with 450 links, or lines of levels, joining the junction points.

The control for the net is provided by determinations of mean sea level by the Hydrographic Survey at the following locations: Halifax, Yarmouth, and Father Point of the Atlantic Coast; Point Atkinson and Prince Rupert on the Pacific Coast. In the most recent adjustment of the net, the tidal station at Churchill, Man., was used as additional control. Local control for leveling on Prince Edward Island employed the tidal station at Charlottetown, and in Newfoundland tidal stations at St. John's and Port aux Basques were used.

Precise leveling employs the method of spirit leveling, using instruments of precision and methods of procedure which have been developed through experience over years of operation and which have been proven to ensure high accuracy.

In the adjustment of the net the condition equation method has been adopted. This method lends itself admirably to the solution of a net of leveling when additions of new work are to be considered. A further improvement was made by using the differential method, which has the advantage of showing the effects of new additions.

The earlier adjustments have been covered in two publications, viz.; "Adjustment of the Precise Level of Canada 1928" and "Recent Adjustments of the Precise Level Net of Canada 1935." In 1950 a new adjustment of the level net was started and was completed in 1952. This 1952 adjustment included all lines leveled to the end of 1951. No publications have been issued incorporating the results of this 1952 adjustment. The differences between the 1952 adjustment and published values do not exceed 0.3 foot except in the mountainous area of British Columbia.

In the early days the lines of precise levels were extended over the railway routes. In time, when railway routes had been covered, the highway routes, primary, secondary, and even tertiary were used to carry the lines. As new routes, railways and highways, are built to open up hitherto inaccessible country where development is progressing, the call for precise levels in the area is satisfied as soon as such work can be undertaken.

Bench marks established by other organizations are correlated within the precise level net. Publications covering descriptions and elevations of all bench marks, by provinces are issued by the Survey. At the present time statistical level publications are as follows:

Precise Level Publications	5
Precise and Secondary Level Publications	3
Bench Mark Publications	4
Altitude Series Publications	14

Considerable work has been done in recent years to provide vertical control in the St. Lawrence Seaway area during the period of construction and for hydroelectric power development.

In connection with hydrological studies of the Great Lakes and the St. Lawrence Waterway, an intensive study of the present crustal movement in the Great Lakes basin has been under way. In furtherance of this study the Precise Level Section has, within the last few years, rerun the level line from the tidal bench mark at Father Point, Que., to Kingston, Ont., via Quebec, Montreal, and Cornwall and also the line from Montreal to Cornwall, via Rouses Point. Between the Great Lakes, lines also have been rerun between Port Dalhousie on Lake Ontario and Port Colburne on Lake Erie; between Toronto Harbor on Lake Ontario and Goderich on Lake Huron; and betweeen Goderich and Collingwood on Georgian Bay. Comparing the new instrumental results with the values obtained years ago over the same lines, the changes in elevation which might take place over a hundred-year period are extrapolated. Graphical illustrations of these changes may

be produced and may be used in the current study of crustal movement in the Great Lakes basin.

An attempt is being made to establish a datum for the Great Lakes which will receive mutual acceptance. This would assist greatly the interpretation of data in hydrological studies.

At the end of year 1955, the leveling covers work in 10 provinces and 2 territories, and the connection of our levels in 3 states of the U. S. A. It is classified as follows:

	Miles
Precise leveling, G.S.C.	36,634
Secondary leveling, G.S.C. and Legal Survey	12,247†
Dept. of Public Works Leveling (DPW)	4,587
Total	53,468
Bench marks established	
G.S.C.	14,565
Legal Survey to 1925	1,163
Total	15,728

There are also many bench marks on D.P.W. lines which have been directly connected by G.S.C. leveling. Some other sections have been adjusted between fixed points of the G.S.C. net.

Astronomy.—The function of the astronomic section is to provide Laplace azimuth control for triangulation and astronomic control for boundary location, to establish second-order astronomical points for control in aerial mapping in areas not covered by triangulation or other types of survey, and to carry out field work and investigations relating to isostasy.

In order to prevent the accumulation of errors in azimuth in a triangulation net, Laplace azimuth stations are established at fairly regular intervals along the chain. This control requires that the astronomic azimuth of one or more lines in the net and the longitude of a terminal of these lines be observed, both to an accuracy of about 0.3 second of arc. Due to the fact that the plumbline or vertical does not coincide with the normal to the adopted spheroid of reference, a small corrective term must be applied to the astronomic azimuth to obtain the geodetic value.

All astronomical observations previous to 1927 were made for the purpose of Laplace determinations, and at most stations latitude observations were also carried out. Since 1927 all precise work at triangulation stations included a star program for latitude, thus obtaining values for the deflection of the plumbline, at these stations. The average deflection in Canada is of the order of 330 feet, with a maximum value of 2053 feet observed in the Gaspé Peninsula.

Longitude and latitude are determined by the use of a Heyde astronomical transit, with self-registering micrometer. Azimuth determinations are usually made with a first-order theodolite, equipped with a very sensitive stride level.

Although astronomical observations are subject to small inherent errors due to deflection, control may be established at any point without reference to observations at another station, and, as such, astronomical observations are often used as control for mapping or as a means of determining boundary location.

To date, 353 precise astronomical observations have been made by the Geodetic Survey. These include 83 Laplace azimuth stations; 300 deflection points (including most of the Laplace points) for investigations in isostasy; and 43 points as control for boundary demarcation, such as the 60th parallel between the Prairie Provinces and the Northwest Territories, or the Manitoba-Ontario boundary.

There are about 1040 astronomic points scattered quite generally over the mainland of the Canadian Arctic and the southern fringe of the Arctic Archipelago. These points have been determined with second-order accuracy for control of small scale aerial mapping. These position determinations were made with a theodolite, using the equal altitude method which gives simultaneous determination of latitude and longitude.

The establishment, by this Survey, of numerous control points along the Arctic coast, the shores of Hudson and James bays and on many of the islands, has resulted in

† Includes 9,261 miles of Legal Survey lines to 1925.

many map coastline revisions. In general, the discrepancies in latitude were of much smaller magnitude than those in longitude. This is easily understandable when it is realized that, in early exploratory work, the longitude was determined by means of transportation of chronometers. Along the east coast of Hudson Bay, it was found necessary to revise about 400 miles of coastline between Great Whale River and Norak Bay, the coastline being previously shown about 30 miles too far west. Elsewhere in the area under consideration, the revisions were usually of the order of three to six miles. The net result was that the area of Hudson Bay is now represented some 12,000 square miles greater than that shown on the maps of the 1930 epoch.

In order to provide control for soundings, charting, and navigational purposes, an astronomic party in 1954 accompanied the United States Navy's Scientific Expedition into the Western Arctic, and again in 1955, the same party carried out similar duties with The Canadian Icebreaker "Labrador" in waters of the Eastern Arctic.

Shoran Trilateration.—Since 1949 a total of 92 stations have been positioned by shoran. This has extended control from a network of first- and second-order triangulation in the southern part of the country to cover an area of more than 2,000,000 square miles.

The electronic instrumentation used in 1949 and 1950 was the modified wartime equipment which has since been gradually replaced by hiran equipment. In 1956 it is hoped to be entirely on the latter basis.

The shoran net is composed of 384 lines of 230 miles average length, with a maximum length measured of 366 miles. It is based upon 18 fixed stations of the triangulation framework. The data have been assembled in toto to permit a unit adjustment of all shoran south of the Arctic coast. This adjustment is currently being reduced on the Univac by the U. S. Army Map Service.

The adjustment of the data had been previously made, by the Geodetic Survey, in 3 parts with results which indicate accuracy at least as high as that of second-order triangulation. The extent of the net is so great that the error in absolute position of the shoran stations cannot be assessed until chains of first-order triangulation reach the areas. The possibility of systematic error must also be taken into consideration.

The pattern of stations is irregular since sites are selected on the basis of accessibility rather than mathematical symmetry. On the average the stations are somewhat less than 150 miles apart. In some inaccessible areas of the perimeter of the net adjacent stations are as much as 300 miles apart. In the area controlled by this net, a point selected at random would likely be within 50 miles and would always be within 150 miles of shoran control. Prior to the shoran net, the nearest horizontal control, other than astronomic, was as much as 1000 miles distant.

Provisional 8- or 16-mile maps of most of this area, for aeronautical use, had been made previously, using trimetrogen photographs and exploratory astronomic control. For economic development or military purposes, larger scale maps are necessary, and the astronomic control is inadequate. Many of the shoran stations have been used as ties for other surveys, even before reliable positions were available from the least squares adjustment. A few of the uses of this Shoran control follow:

(1) *Topographical mapping.*—In hilly or mountainous sections of the country, control for 1:50,000 (or 1 mile) map sheets is obtained from third-order triangulation done with the accent on speed instead of accuracy. These surveys benefit from ties to shoran control.

(2) *Shoran recorded photography.* — A method has been developed whereby shoran coordinates are obtained for each photo of a vertical strip. Suitable points on these photos are then evaluated and used to control the vertical coverage in the area. This method can provide horizontal control over a large inaccessible area faster than any other known method. In reconnaissance for the mid-Canada radar line in 1954 this method was used to provide control for 1:50,000 maps along a strip nearly 800 miles in length across rugged terrain in Quebec and Labrador.

Using eight stations of the main shoran net that had been fixed in 1953, and adding five more stations in carefully selected locations, it

was possible to provide control for shoran photo over an area of some 300,000 square miles. For this project vertical control was provided by Profile Recorder. Using this combination, topographical maps of a very large area were drawn with the only ground occupation being the 13 shoran stations. This example is the most dramatic application of shoran control that we have on record. From the start of measuring the basic net to production of topographical maps barely 18 months had elapsed. In other areas shoran recorded photography for topographical mapping is proceeding in a more orderly fashion in large areas where the discovery of oil, gas, or minerals has necessitated a topographic mapping program on a "crash" basis.

(3) Other applications: With the development of high precision bridging instruments and also that of analytical aerial triangulation, it is possible that shoran control points can be utilized in still another way.

Methods of Adjustment.—The geodesist has also been given the task of processing the data by more rapid methods, without loss of accuracy, so as not to delay production of cartography. Towards this an investigation of methods of solving linear equation systems was pursued, having in mind the considerations:

(*a*) Suitability of the method for the use of desk calculators, and

(*b*) A method whereby several computers could work simultaneously and independently to achieve the solution in toto for the system of equations.

The result of the investigation is characterized by two main features:

(*a*) The selection of the Bjerhammar method of elimination, and

(*b*) The arrangement of the system of equations to obtain independent units, each of which contains approximately 15 equations. In the independent units the equations are arranged to obtain the maximum number of mutually orthogonal equations.

The Bjerhammar method of elimination was chosen because:

(*a*) It is a compact method with adequate checks or controls;

(*b*) There is no change in procedure for computing and checking correlate values;

(*c*) It contains the elements for modifying the original equations in such a manner that the usual backward solution for correlates is eliminated. The modified correlates which are used with the modified equations are also contained in the elimination. This method is used for investigating the differential effects of selected equations on the corrections; and

(*d*) It contains the necessary elements for computing the inverse matrix of the normal equations, should it be required.

In the arrangement, a system of equations is divided into units such that each unit has no direction in common with the other. The equations which are removed from a consecutive arrangement are placed after the independent sections and are used to unite these sections. The number and selection of independent sections in an adjustment is more or less arbitrary and depends on the number of equations, the nature of the geometric figures, and the number of equations which can be conveniently handled as a group. For our present elimination sheets (21 columns and 41 lines) we usually select a group of about 15 equations. This enables us to write the sectional normal equations and eliminations on one sheet. With this arrangement, the adjustment is assigned to several computers, and each has the advantage of working on a single sheet. An adjustment containing 75 equations was divided into five units, each of which was given to a man. The solution, which was completed in four days, was confined to ten sheets.

Combination of the independent sections is a cooperative effort. For each row of the elimination several elements from each sheet must be transferred to other sheets before independent computations can be again commenced. The union of the sections is accomplished in one of two ways:

(*a*) The correlate values for the whole system are computed. This is achieved independently for each section after transfer among the sections of a few elements. Corrections are derived independently for each section.

(*b*) The corrections for the independent sections are computed and the combining equations are modified. The partial corrections obtained from the modified equations are added algebraically to the sectional corrections to obtain the corrections for the complete system. Thus

the usual backward solution for the whole system is eliminated.

In each independent section we first tabulate all the angle equations which will produce mutually orthogonal normal equations. The remaining angle equations are tabulated next and finally the side equations. For a chain of quadrilaterals mutual orthogonality can be obtained for approximately one-half of the total number of equations.

It should be noted that orthogonal equations are not altered when the method of modified equations is used.

The advantages of this approach of adjustment are as follows:

(*a*) Large adjustments can be completed in a relatively short time,

(*b*) The work of adjustment can be divided among several computers,

(*c*) One computer can complete an adjustment in less time,

(*d*) Computational errors are more quickly detected and corrected, and

(*e*) The method of modified equations facilitates the investigation of partial corrections contributed by specified equations.

Long Lines.—Since the land of Canada extends almost to latitude 85°, it became necessary, in 1947, to investigate the suitability of formulas towards the calculation of azimuth and distance in high latitudes for the lengths of line which can be measured by electronic means. This led to an adaptation of Jordan's formulas and to the construction of the necessary tables.

With the shoran operations under way in 1949, little time was available to continue investigation of the extent to which the tables might prove ineffective in securing accurate results of calculation as higher latitudes were approached. Previous to publication* the accuracy of formulas and tabular values had been tested in application to a line 1,446 miles in length situated in mean latitude 70° with resulting discrepancies of 0″.001 in latitude, 0″.001 in longitude, and 0″.000 in azimuth.

Since the shoran trilateration is now being extended beyond latitude 70° the matter has been further investigated with the results indicated in the tabular statement. The method of Sodano and that of Bodemuller, which is an extension of Helmert's formulas to apply to lines of great length in any latitude, have been used as the yardstick. Both of these methods require 10-figure computation. The Canadian method is based on 8-figure logarithmic computation. Slight discrepancies due to errors in the 8th place after the decimal point may affect the result and show in the comparison. Methods used for computing geographic positions in conventional triangulation are not adequate.

The greatest discrepancies in the Canadian application occur in the azimuths of 3, but these are not considered significant in shoran in medium latitude and less so in high latitude. The extent of the convergence in this example directs attention to the fact that the discrepancies are most insignificant.

We are now convinced that the formulas and tabular values are sufficiently accurate for lines of shoran length for the latitude range of 40° to 85°.

PRESENT STATUS

The illustrations permit a rapid assessment of the extent to which the Geodetic Survey has contributed control towards better maps. The vast area of the north is gradually being delineated accurately through the information supplied by the photo-coverage and the control which is increasing throughout the area. At the present, photo-coverage exists for the entire country, of which about 70% is vertical, 25% is trimetrogon, and the rest is a remnant of the older oblique photography.

The basic control is in a period of transition. Exploratory astronomic fixation is deficient in many ways for mapping control. Precise astronomic fixation, as its name suggests, is more accurate instrumentally, but nevertheless difficulties also arise in its use, due to the deflection of the vertical. The shoran trilateration is superior to astronomic fixation, but it will have to give way ultimately to first-order triangulation.

Electronic measurement of length is in its infancy, but within a few years it may be possible to break down vast areas by precise

* Geodetic Problems in Shoran—J. E. R. Ross.

traverses of electronic length measurement and angular observations between control points to a degree not visualized by present methods, thereby increasing the density of control of an accuracy sufficient for most purposes.

COMPARATIVE RESULTS OF INVERSE CALCULATION OF LONG LINES IN HIGH LATITUDE*

	Lat.	*Long.*	*Formulas*	*Azimuth*	*Length* (m.)	*Azimuth*
1	80°	98°	(a) Canadian Geodetic Survey	25° 12′ 22″.322	537,861.551	225° 01′ 38″.175
	84	78	(b) U.S. Army Map Service	22″.323	1.547	38″.179
2	78	98	(a)	77° 45′ 53″.411	576,105.153	282° 14′ 06″.589
	78	73	(b)	53″.411	5.108	06″.589
3	85	100	(a)	40° 06′ 27″.322	855,195.04	319° 53′ 32″.678
	85	00	(c) Bodemuller (Helmert)	27″.349	855,195.18	32″.651
4	72	85	(a)	13° 53′ 39″.429	1,661,053.95	238° 20′ 12″.231
	85	40	(c)	39″.428	1,661,054.14	12″.212
5	72	0	(a)		1,451,443.68	
	85	0	(c)		1,451,443.69	

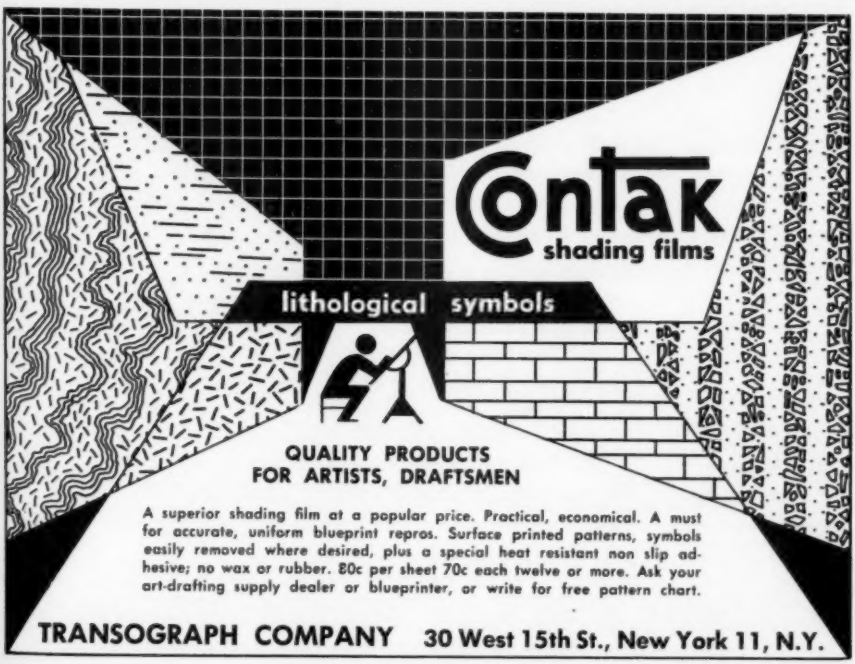
* Clarke 1866 Spheroid

(a) Geodetic Problems in Shoran, J. E. R. Ross.

(b) Inverse Computation for Long Lines, Tech. Report No. 7 (205233), Sodano.

(c) Publication Nos. 13 and 18, Series B, German Geodetic Commission.

(*Continued on page 442*)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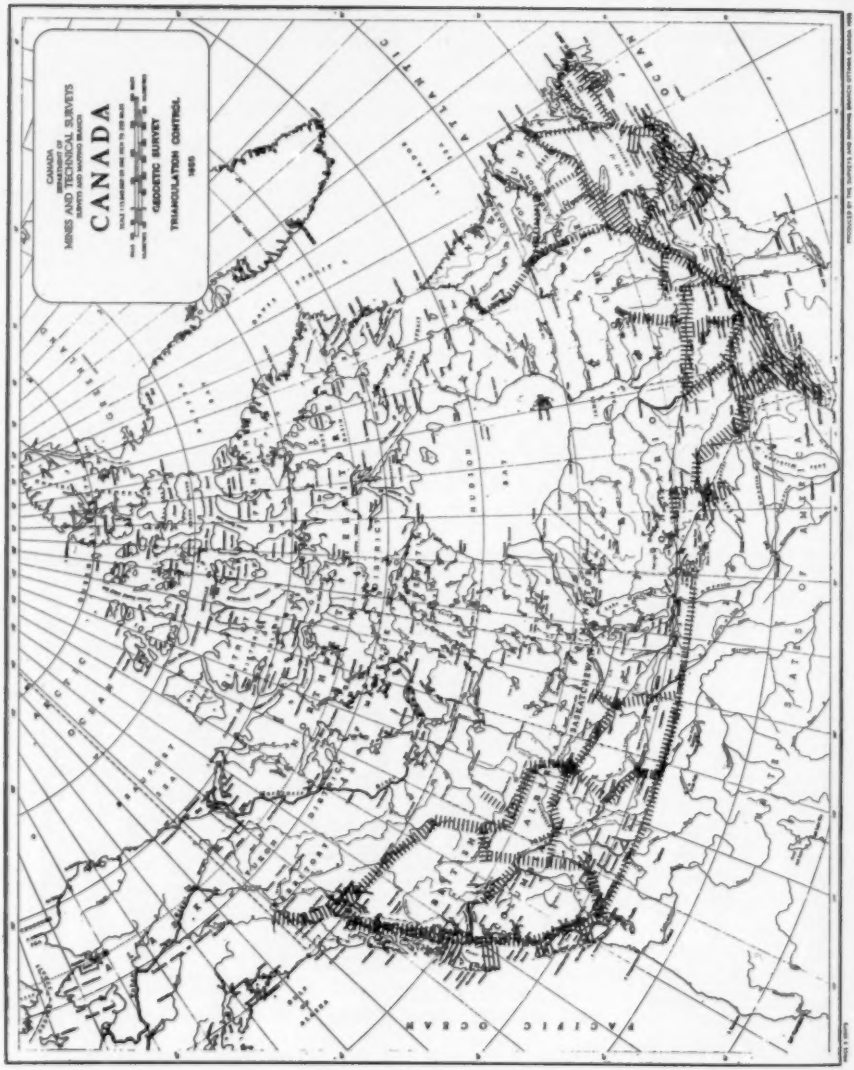
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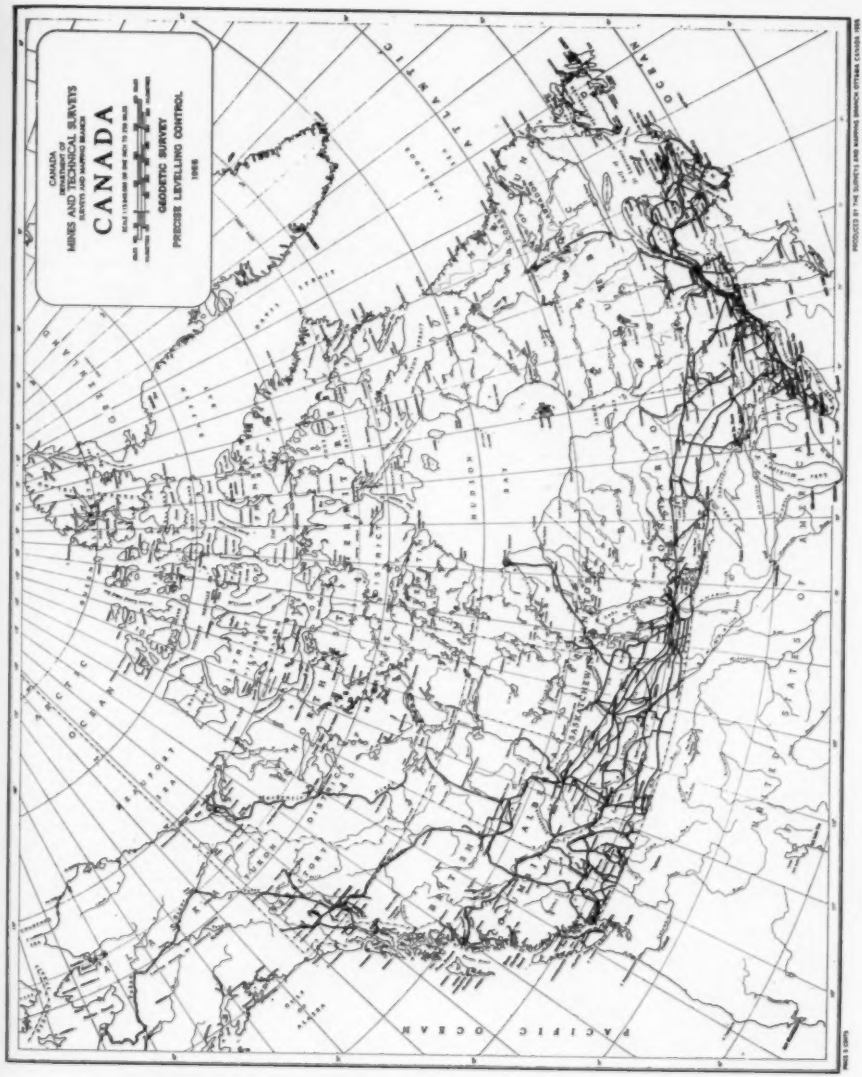
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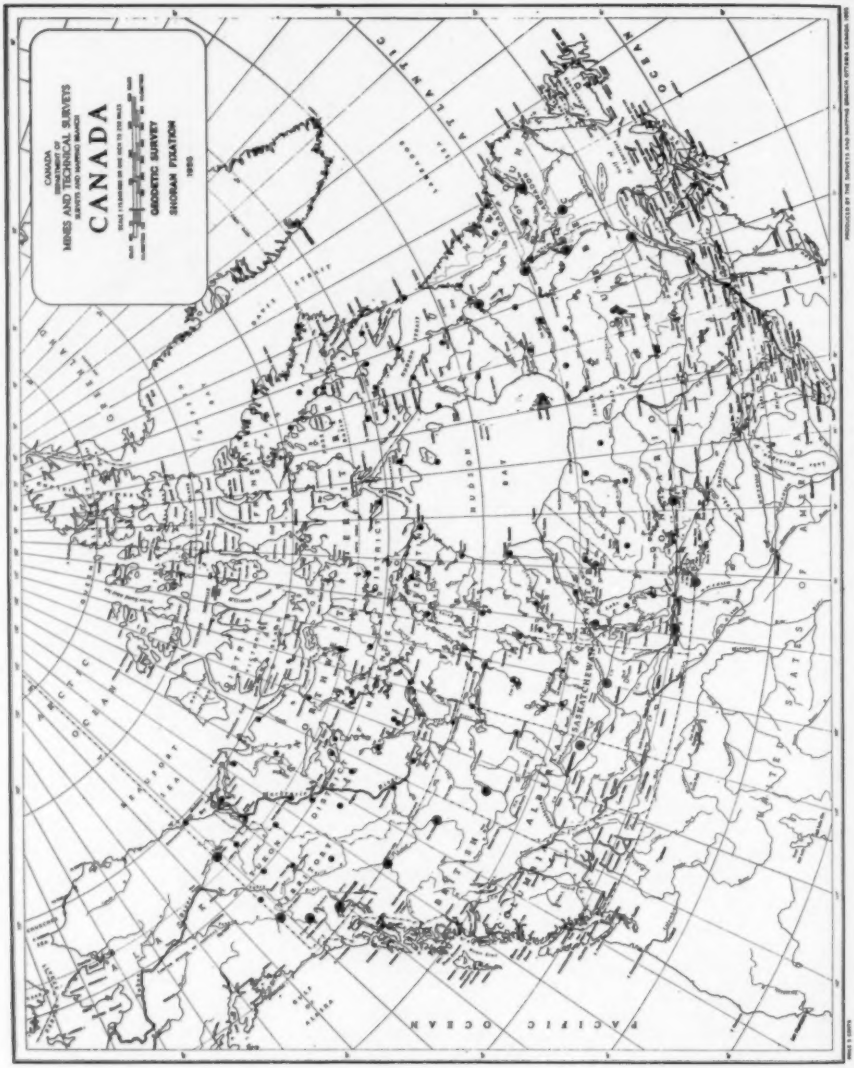
UNITED STATES OF AMERICA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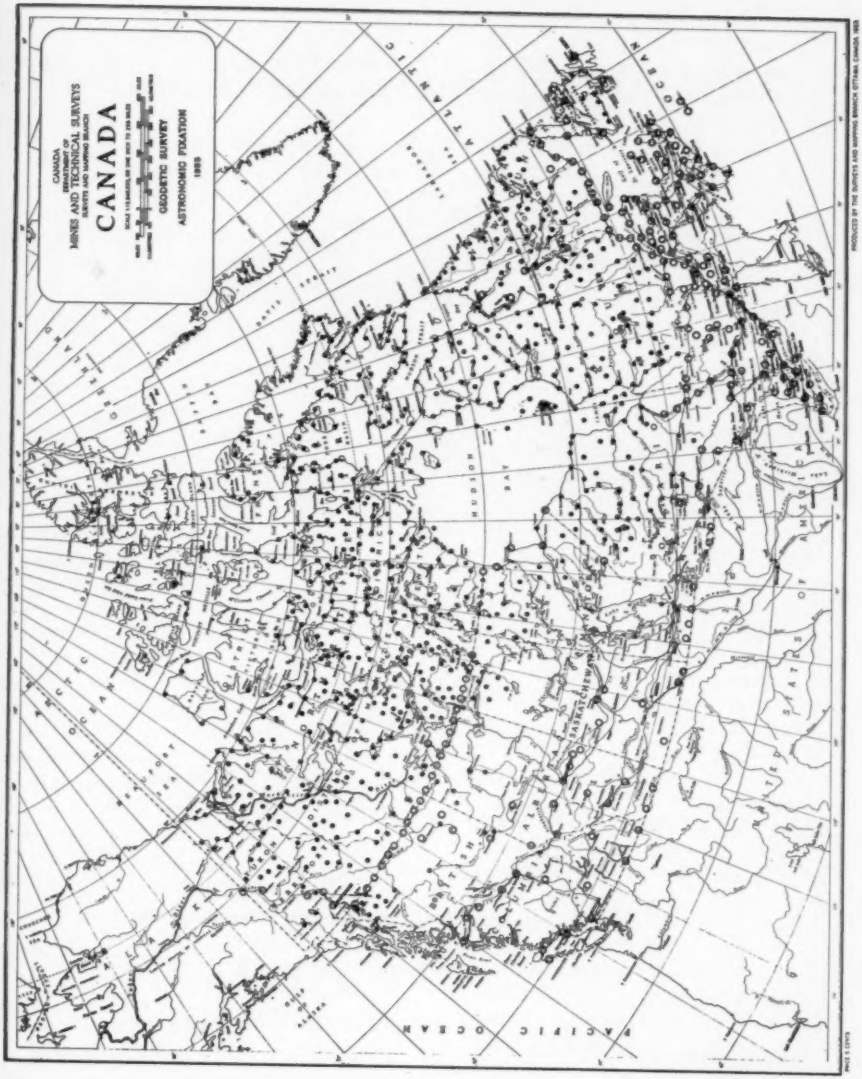
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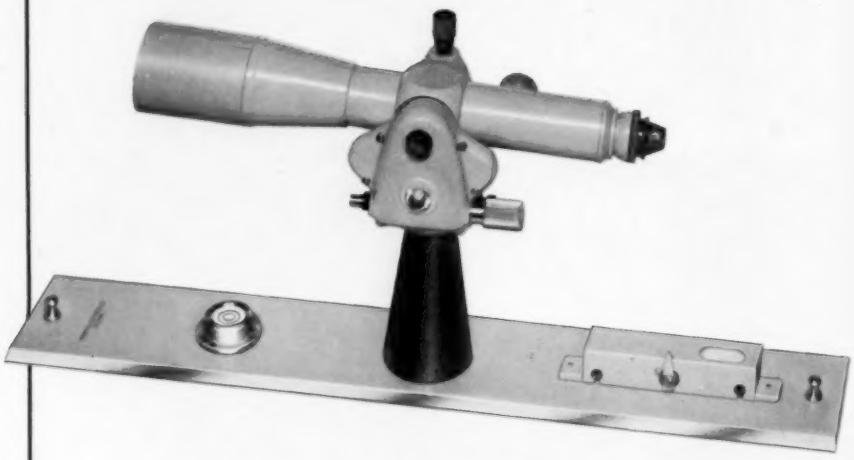

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The National Mapping Program—A Review of Progress

By GERALD FITZGERALD[1]

CHIEF TOPOGRAPHIC ENGINEER, U. S. GEOLOGICAL SURVEY

IN 1777 the Continental Congress authorized the appointment of a surveyor to "take the sketches of the country and the seat of war." Each year since then the Federal Government has made some progress in surveying and mapping its vast domain. Much of the early work, before the Civil War, was done under the direction of the Corps of Topographic Engineers of the Army. After that war, several new organizations were created to carry on geographic and geologic explorations, principally in the western part of the country. The most important of these organizations were the Hayden, Wheeler, Powell, and King Surveys. In 1879 they were superseded by the United States Geological Survey, largely as a result of a recommendation by the National Academy of Sciences.

After discussing the functions of the new organization with members of Congress, the first Director of the Survey, Clarence King, concluded, in part, that "The intention of Congress was to begin a rigid, scientific classification of the lands of the Public Domain for the general information of the people of the country, and to produce a series of land maps which would show all those features upon which the intelligent agriculturists, miners, engineers, and timbermen might hereafter base their operations, and which obviously would be of the highest value to all students of the political economy and resources of the United States." And so the systematic mapping of the United States and its possessions became a major responsibility of the Geological Survey.

Presented at the Sixteenth Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., March 19–21, 1956.

[1]Publication authorized by the Director, U. S. Geological Survey.

EARLY TOPOGRAPHIC MAPPING

Major John Wesley Powell, the second Director of the Survey, can be credited with establishing what we now call the National Topographic Map Series. In 1884 Powell appeared before the Appropriations Committee of Congress and estimated that the Survey could map the United States completely in 24 years at a cost of $18,000,000. Although Congress did not see the necessity of the broad program suggested by Powell, it has annually appropriated funds specifically for topographic surveys.

Under Powell's leadership, specifications were prepared for the topographic map coverage of the United States. By 1885, work was in progress on three series of maps. The 1-degree quadrangle series, at the scale of 1:250,000, was used for undeveloped areas, mainly in the West. The 30-minute quadrangle series, at the scale of 1:125,000, was used for areas of average detail and development. And the 15-minute quadrangle series, at the scale of 1:62,500, had already been adopted for the mapping in Massachusetts and New Jersey. The inadequacy of the small-scale of 1:250,000 was soon recognized, and only a very few areas were were mapped at that scale after 1889.

In the early days of the Survey, a topographer was equipped with a rather crude planetable on a tripod, an 8-inch open-sight alidade, and a light mountain transit. Barometers were used for determining elevations until the vertical-angle arc was added to the new telescopic alidade. Coast and Geodetic Survey triangulation was supplemented by less accurate surveys to provide the necessary horizontal control. In 1896 Congress authorized the Geological Survey to establish control elevations by spirit leveling and to set permanent bench marks. In

the early 1920's, photogrammetry based on aerial photographs began its long, vital, and eventually predominant association with topographic mapping.

Although the period between the two World Wars brought many improvements in methods and techniques, the mapping program as a whole lagged badly. Seldom were enough funds available for producing a hundred quadrangle maps a year. In 1925, Congressman Temple of Pennsylvania introduced a bill that provided for completing the map coverage of the United States in 20 years. The Temple Act became law, but funds were not appropriated to support it. World War II found the Nation's mapping agencies unprepared to meet the needs for military operations and civil defense.

World War II, however, succeeded in accomplishing what World War I had apparently failed to do—it demonstrated conclusively that maps are critically needed and that a production rate of a hundred maps a year cannot even keep up with the rate of obsolescence. To meet the unprecedented demand for topographic maps, the Army Map Service was established and the mapping facilities of the Coast and Geodetic Survey, Tennessee Valley Authority, Forest Service, and Geological Survey were all expanded. The Bureau of the Budget set up a special office for the purpose of coordinating the mapping activities of Federal bureaus and establishing standard specifications for maps in the National Topographic Map Series, which were designed to serve both military and civilian needs.

Scientific and engineering research, which has been so successful in developing methods that combine precision with mass production techniques, was also applied to the problem of meeting the demand for topographic maps. Photogrammetry became an even more important part of mapping procedures. But it was not until the postwar era that mass production methods really became effective in producing maps.

MAPPING IN THE POSTWAR ERA

Our expanding economy and growing population have constantly increased the demand for new industrial plants, power facilities, improved highways, homes, shopping centers, churches, schools, and recreational areas. More and better maps were needed to investigate, plan, and build all these new developments. And, at the same time, the high-priority map requirements of the Department of Defense continued to grow.

Another factor complicated the problem of supplying the required maps—namely, the far greater demand for larger scales. Before Pearl Harbor, the 15-minute maps at the scale of 1:62,500 were adequate for most needs. But in the postwar period, most users preferred the 7½-minute maps at the scale of 1:24,000. The increased cost of larger scale maps has greatly reduced the map coverage possible with available funds. As the agency primarily responsible for domestic mapping, the Geological Survey has had to consider all these problems and develop an organization that can cope with them.

The Topographic Division is one of the four technical divisions of the Geological Survey. Since 1946, the Division has consisted of a staff headquarters office in Washington; a Special Maps Branch, also in Washington; and four regional field offices, in Arlington, Va., Rolla, Mo., Denver, Colo., and Sacramento, Calif. The Washington staff develops long- and short-range plans, coordinates the mapping program, directs research in equipment and techniques, prepares map specifications, and develops standard mapping procedures. The four regional offices plan the detailed mapping operations, prepare the map manuscripts by photogrammetric and field methods, and supply finished materials for reproduction. The Special Maps Branch prepares small-scale maps and charts, including—at the present time—maps of Antarctica in connection with the International Geophysical Year and the operations of Task Force 43. Map materials prepared in the four regions and Special Maps Branch are printed and distributed to the public by the Publications Office of the Survey.

To greatly expedite the completion of topographic map coverage for the country, a general plan was formulated 10 years ago.

This plan includes the following important elements:

(1) Use of the most modern techniques in preparing the maps;
(2) Adoption of engineering standards of accuracy for all surveys and maps;
(3) Greatly expanded activity in research and development to provide new instruments and techniques that are both more accurate and more economical;
(4) Planning and controlling the production operations so that field and office forces are used efficiently and the peaks and valleys of the production schedule are reduced to a minimum.

It can easily be seen that carrying out this plan is a formidable undertaking. The work program now contains some 10,000 authorized quadrangles, and all the production phases, from initial planning to final reproduction, must be kept reasonably well balanced over a period of 4 to 6 years.

Production has been designed to take the fullest possible advantage of photogrammetric procedures, although conventional field surveys are still needed to provide ground control and to complete the content of the maps. The major phases of the production cycle are aerial photography, control surveys, photogrammetric compilation, and field completion surveys. The finishing operations consist of color separation by scribing or drafting, map editing, and reproduction by photolithography.

Although the general methods used today do not differ radically from those of 10 years ago, they have been modified considerably through research and development. For example, the staff section of photogrammetry has devoted its research and development efforts toward exploiting the possibilities of photogrammetry. A coordinated attack was made on three major fronts—aerial photography, photogrammetric instruments, and techniques and standards. By considering the interrelated effects that these elements have on each other, the concept of a unified photogrammetric system was evolved. Consequently, the development work on each separate element proceeded at a controlled pace so that its effect on the complete system could be fully evaluated.

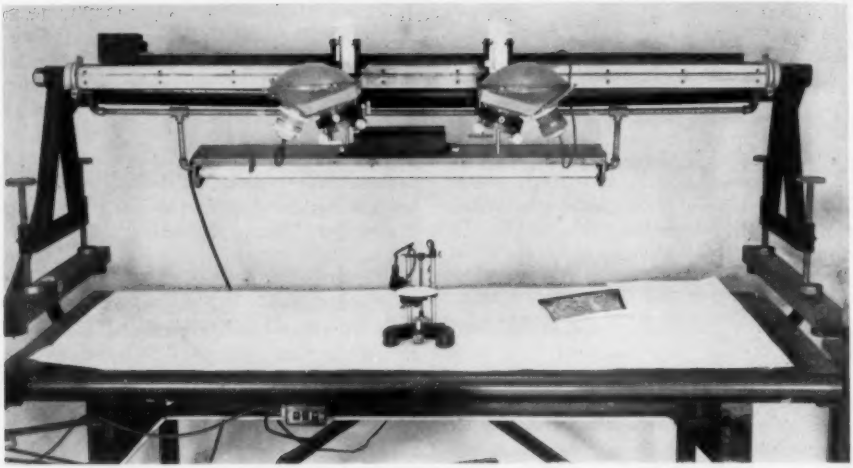
Successful photogrammetric mapping demands high-quality photographs. Moreover, the photographic coverage must be intelligently planned for maximum efficiency and economy in the ground control and photogrammetric compilation phases. Significant improvements in the last decade include new cameras and lenses, twin camera mounts, new techniques for calibrating cameras, and better methods of flight planning. These improvements have paid large dividends in the form of better mapping photographs.

Stereoscopic plotting equipment has received the lion's share of attention in the past 10 years. The multiplex and its accessories, the diapositive printer and tracing table, have all been greatly improved. A new plotter developed by H. T. Kelsh and other members of the Geological Survey has made an important contribution to stereomapping and is widely used by government agencies and private industry.

Perhaps the most important new development in photogrammetric mapping is the perfection of a system for effectively using twin low-oblique photography. A key element in this system is the new ER-55 projector, used on the Twinplex plotter for stereotriangulation and on the ER-55 plotter for compiling map detail. The system as a whole provides one of the most efficient and modern means for compiling medium- and small-scale topographic maps.

Other developments that have increased map accuracy and decreased costs are variable-ratio pantographs for use on direct-projection stereo-plotters and stereotemplet triangulation, a new and highly effective tool for the photogrammetric extension of ground control. Another recent development is the orthophotoscope, which converts conventional perspective photographs to the equivalent of orthographic photographs. Mosaics prepared by the orthophotoscope are expected to find wide application in mapping, engineering, geology, forestry, and other scientific fields.

The basic procedures for control surveys, which are relatively costly, have not changed materially in the past 10 years. Much experimenting has been done with new instru-



New photogrammetric instrumentation. ER-55 projectors, arranged for the compilation of convergent low-oblique photography, mounted on a standard multiplex frame.

ments and techniques, including those that employ electronics in measuring heights and distances. Thus far, however, most of these new developments have not yet proved economical in providing control for other than reconnaissance mapping. On the other hand, helicopter transportation has greatly facilitated fieldwork in many areas, particularly in the Western States and Alaska.

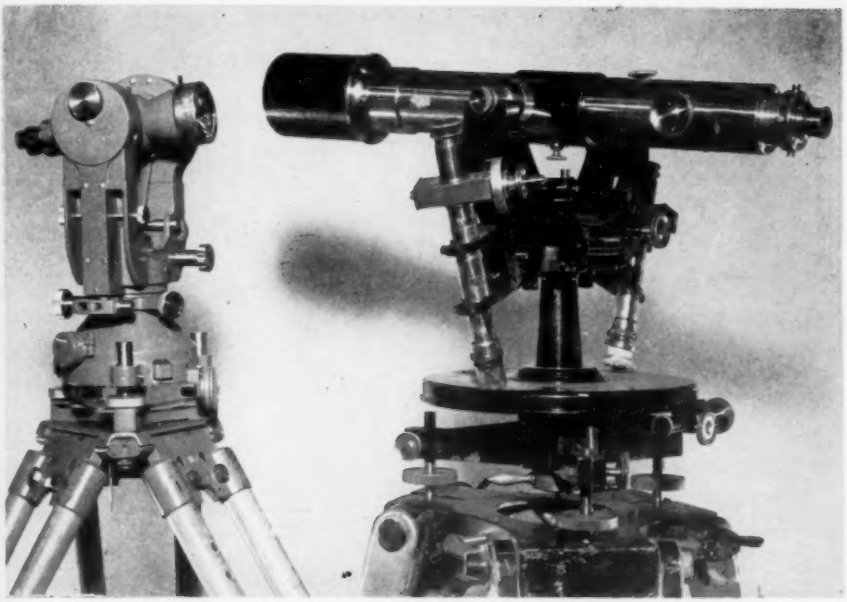
An important new development in cartography is the technique known as scribing, in which map details are engraved through a semiopaque coat of paint applied to a sheet of clear plastic. This technique is quite similar to the negative engraving that has long been done in photolithographic reproduction processes. Scribing has already been fully adopted in the color-separation phase of map finishing, where it has both improved the appearance of the maps and greatly increased the rate of production. Scribing has also largely superseded penciling or inking in the stereocompilation and field completion phases. An investigation is now underway to determine whether it is feasible to separate the map colors at the time of photogrammetric compilation. If successful, this procedure will further expedite production and reduce costs.

A DECADE OF PROGRESS

The topographic map production of the Geological Survey has increased tremendously during the past 10 years. As already mentioned the average output before World War II was no more than a hundred maps a year. During fiscal year 1946, the beginning of our 10-year period, about 200 quadrangle maps were published. The annual production rate has increased steadily so that we can report a total of nearly 1,600 maps for 1955.

This increase in production over the prewar rate is, of course, closely related to the increase in available funds. From $5,000,000 in 1946, funds for topographic mapping rose to a maximum of $17,500,000 in 1952, which includes a transfer of $4,000,000 from the Department of Defense. In 1954 and 1955, available funds leveled off at about $14,700,000.

Although production is geared to funds, the relationship between the two has not been directly proportional in the past few years. Even with a decrease in funds, production has continued to increase materially for two important reasons. The first is that our operational force is more stable and better trained, and the second is that our



Progress in field instrumentation. An old-time theodolite used in early surveys by the USGS is shown at the right. At the left is an up-to-date T-2 theodolite used in current USGS surveying.

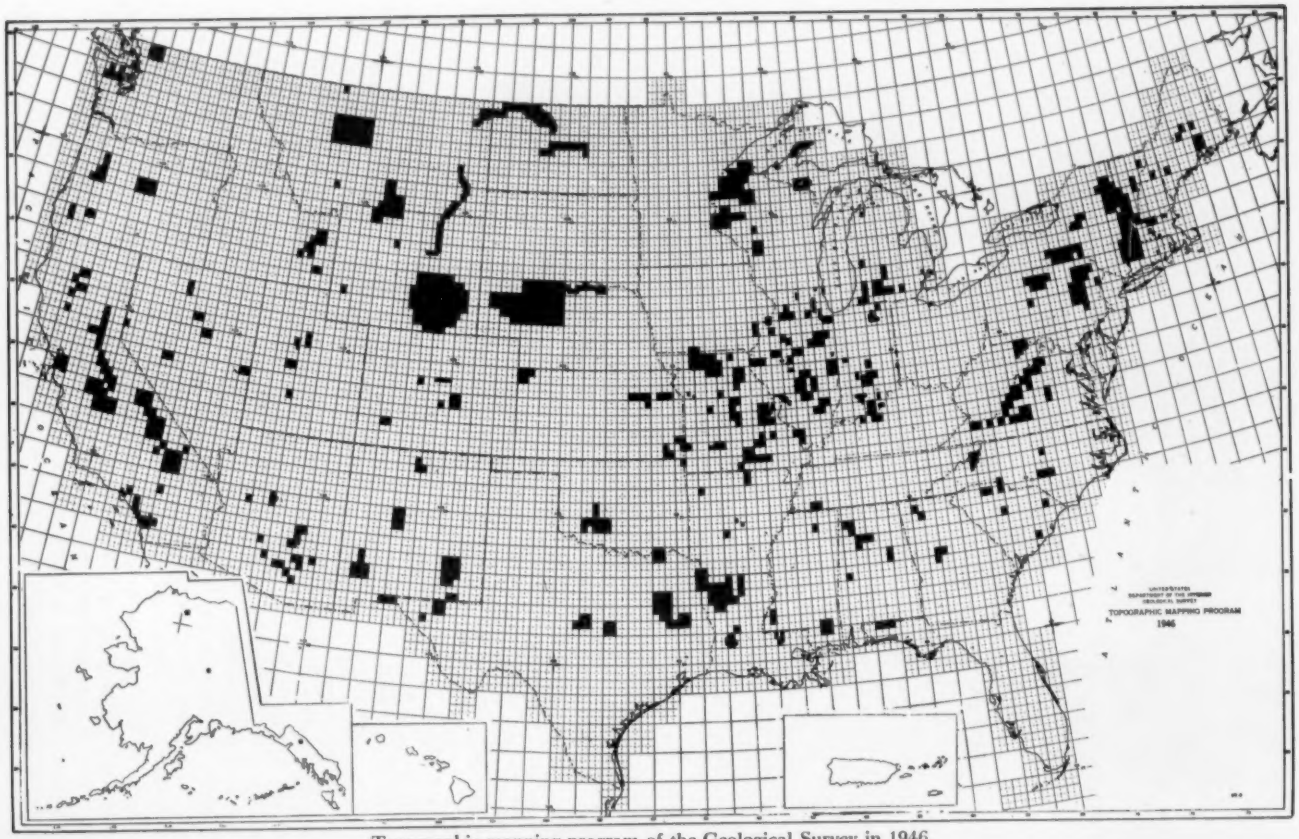
research and development program is paying off.

The total funds for topographic mapping include those made available through cooperative agreements with States and local governments. Cooperative funding is on a 50-50 basis, with the Survey supplying its share from direct appropriations. Cooperative funds have increased from $468,000 in 1946 to $1,233,000 in 1955, at which time 33 States and Puerto Rico were cooperating. This type of program has contributed significantly toward the completion of the National Topographic Map Series and has been a part of the overall mapping program of the Survey since 1884.

Mapping requested by the Department of Defense has occupied about half the capacity of the Survey during the past decade, and mapping now planned to meet military requirements will not be completed until 1965. This program includes mapping in all 48 States, Alaska, and Hawaii and totals nearly a million square miles.

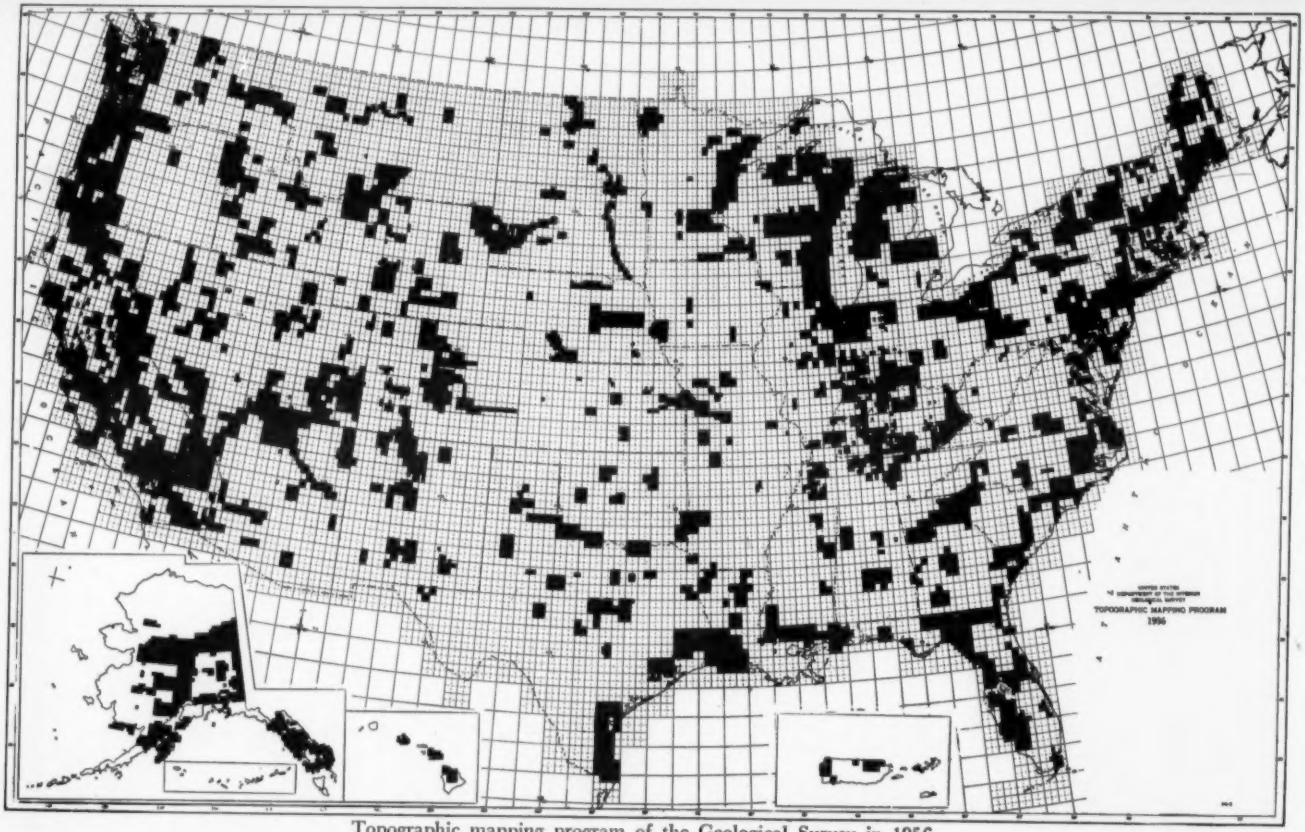
In 1946, mapping was started in the Missouri River Basin as part of the development plan for that area. About 80,000 square miles of the Basin have been mapped, and the program is still in progress.

Notable contributions to the national mapping program have been made by several Federal agencies other than the Geological Survey. In addition to providing the basic framework of first- and second-order control, the Coast and Geodetic Survey has prepared manuscript copy for the 7½-minute map series in connection with its hydrographic surveys of many of our coastal areas. The Army Map Service has made standard-series quadrangle maps of many high-priority areas in the States and Alaska. Within the next few years the U. S. 1:250,000 series, an Army Map Service project, will provide the first uniform-scale topographic map coverage of the entire country. The Forest Service and Tennessee Valley Authority have made important contributions by mapping limited



Topographic mapping program of the Geological Survey in 1946.

Topographic mapping program of the Geological Survey in 1946.



Topographic mapping program of the Geological Survey in 1956.

areas in which they have a special interest. The national mapping program is coordinated under the supervision of the Bureau of the Budget so that all the maps produced meet uniform specifications and are published as a part of the National Topographic Map Series.

In addition to preparing and publishing more than 10,000 maps in the 7½- and 15-minute series, several other major projects have been undertaken in the past 10 years. The Alaska Reconnaissance Series, at the scale of 1:250,000, was compiled at high speed from existing source material to provide complete, uniform coverage for the 600,000 square miles of the Territory. Also, since 1948 more than 100,000 square miles of inch-to-the-mile mapping have been completed in the more important parts of Alaska, and nearly 500 quadrangle maps have been published. As the Department of Defense has placed a high priority on mapping in Alaska, the current program calls for an additional 300,000 square miles of inch-to-the-mile mapping by 1962, plus complete revision of the provisional quarter-million-scale maps.

Specifications and standards for the 1:500,000-scale State base maps have been revamped, and many of the new maps have been published. Others are in preparation and will be completed as new source data become available. Most of these maps will be published with relief shading.

In response to widespread demand, special-format maps of our more important cities are being prepared for publication at the scale of 1:24,000. These maps are especially suitable for use in civil and military defense activities.

At the request of the U. S. Air Force, the Special Maps Branch has compiled small-scale maps and charts of 7½ million square miles in various parts of the world. It has also completed many special mapping projects for other Federal agencies and for all divisions of the Geological Survey.

The increased production of topographic maps and the wider knowledge of their availability have naturally enlarged the task of distributing them to the public. The annual rate of distribution has risen from 1,000,000 copies in 1946 to 3,200,000 copies in 1955 and is expected to reach 4,000,000 copies this year. To meet this demand, the Survey has established three main distribution offices, located in Washington, D. C., Denver, Colo., and Fairbanks, Alaska. These facilities are supplemented by 11 other Survey sales offices in Western cities and by 425 commercial agents throughout the States and Alaska.

In line with the expanding program of production and distribution, a better system has been established for determining the requirements of map users. Under this system, developed by the Survey in conjunction with the Bureau of the Budget, the 20 or so principal map-using agencies of the Federal Government present annual statements of their needs to the Survey. The needs of State agencies are also considered. In 17 States, mapping advisory committees have been set up to review the mapping situation in their States, recommend priorities, and consult with the Survey on specifications. Several more of these committees are in the process of formation, and it is hoped that eventually all the States and Territories will be represented in this manner.

THE FUTURE PROGRAM

In 1946, a proposal for completing the topographic mapping of the country was presented to the Bureau of the Budget. It was estimated that about 25 percent of the United States was adequately mapped and that to complete the job would cost more than $400,000,000.

Since then, much has been accomplished even though the funds available have been only about half the amount recommended in the 1946 plan. Moreover, costs have greatly increased for all the elements that go into the making of a map, such as salaries, transportation, and equipment. Nevertheless, during fiscal 1955, new mapping was completed for about 4 percent of the country, and according to our current appraisal of published quadrangle maps, adequate coverage is now available for about 37 percent of the Nation's area.

Today we estimate that adequate topo-

graphic coverage can be provided for the rest of the United States in 17 years at a cost of about $220,000,000. This estimate is based on the following assumptions:

(1) That funds will be made available at the present annual rate;
(2) That the rate of accomplishment will proceed as expected; and
(3) That the present concept of map scales, contour intervals, and content will remain adequate. It should be emphasized that the cost of a maintenance program of map revision is not included here.

By adding the amount expended during the past 10 years to the present estimated cost of completing the job, we obtain a total figure of $328,000,000 as compared to the 1946 estimate of $400,000,000. Thus, a drop of almost 20 percent in estimated total cost has been achieved in spite of inflation, demonstrating the improvement in production efficiency that has already resulted from our research and development program.

Despite the progress made since World War II, a great deal still remains to be done. With the job less than half finished and the necessary revision program far behind schedule, research and development must be continued in both photomapping and ground-surveying techniques. I am confident that the other Federal mapping agencies and the progressive commercial firms in the mapping field will continue to cooperate with the Geological Survey in working toward the early completion of the National Topographic Map Series.

DISCUSSION

COLONEL JULIAN D. ABELL*—As Mr. FitzGerald has pointed out, mapping within the United States began at the time of the Revolutionary War. We date the birth of military mapping with the appointment of Capt. Robert Erskine as Geographer and Surveyor of Roads for the Continental Army. Subsequent to the Revolutionary War, military mapping was carried out in a rather spasmodic fashion. The establishment of the Corps of Topographical Engineers in 1838 provided a stimulus but the work of the Corps was devoted principally to the support of rivers and harbors improvement. After the merger of The Corps of Topographical Engineers and The Corps of Engineers during the Civil War, military mapping made little progress. Even World War I failed to demonstrate decisively the need for military maps.

It remained for World War II to emphasize that need. During that war the several War Department agencies engaged in mapping were combined to form the Army Map Service under the direction of the Chief of Engineers. Following the war, a long-range military mapping program was established to meet the requirements of the Department of Defense for topographic maps. The outbreak of the emergency in Korea forced an expansion of the program and demonstrated a need for more rapid execution. The capacity of the Army Map Service base plant was increased, field offices were established to broaden the production base, and contracts were entered into with commercial firms.

As previously mentioned, the mission of the Army Map Service is to provide the topographic maps required by the Department of Defense. The major part of the productive capacity of the Army Map Service is devoted to mapping of foreign areas. Domestic mapping is the responsibility of the United States Geological Survey and very little capacity is devoted to large-scale mapping of domestic areas by the Army Map Service. We do undertake certain mapping for which there is an urgent need or covering military training areas, but by and large the requirements of the Department of Defense are met by the Geological Survey. Our arrangement provides for conversion of the civil edition to a military edition by the addition of the UTM grid and conversion to the standard military scale.

Perhaps the major contribution of the Army Map Service to domestic mapping is the preparation of the 1:250,000-scale map series covering the entire country. The program, comprising 468 sheets, is to be completed through the compilation stage by the end of 1957. In fiscal year 1955 and thus far in 1956, 176 compilations have been completed by stereophotogrammetric methods with 15 more to be completed by the end of the fiscal year. In addition, during this period, 42 sheets have been newly compiled from existing larger-scale maps or have been photo-revised as part of the continuing maintenance program.

The Coast and Geodetic Survey, under cooperative arrangements with the Army Map

* Commanding Officer, Army Map Service

Service, is preparing a military edition at the scale of 1:500,000 covering the United States and parts of Mexico and Canada. They are preparing 73 of the 87 sheets in the project—Army Map Service has completed the other 14 sheets. The military edition is being prepared using the Coast and Geodetic Survey 1:500,000 Sectional Aeronautical Charts as a base, omitting the aeronautical navigational data and adding the UTM grid data, road route markers and Army Map Service marginal data. Estimated completion date for the project is 31 December 1956.

The Geological Survey, under cooperative arrangements with the Army Map Service, is preparing 1:1,000,000-scale maps from the completed Army Map Service 1:250,000-scale maps. Fifteen (15) of the forty sheets covering the United States have been placed in work this fiscal year.

Production of three-dimensional maps of the United States has continued during fiscal year 1956. Fourteen 1:25,000-scale models have been completed, two of six scheduled 1:50,000-scale models have been completed and two 1:250,000-scale models are in work.

Due to the high priority of the Alaska mapping, an Army topographic survey unit, the 30th Engineer Group, was assigned to Alaska to establish field control in support of the large-scale mapping requirement of the area. This Group, under direct operational control of the Army Map Service, completed their mission with the close of the 1955 season. Sixty stereocompilations of Alaska at 1:50,000 scale have been completed by Army Map Service during fiscal years 1955 and 1956, utilizing the basic and supplemental ground control established by the 30th Engineer Group.

The Army Map Service is particularly interested in improvement in equipment, procedures, and techniques. We have maintained close liaison with the work of other agencies and our working relationships are most satisfactory.

A current Army Map Service developmental project expected to have far-reaching effects is concerned with the derivation of a new value for the figure of the earth. A preliminary value has been computed. With the launching of the earth satellite and subsequent observations, the results of this work can be proved. The derivation of this preliminary value was made possible by the acquisition of data on two long arcs. These arcs are a meridional arc extending from South Africa to Scandinavia—the so-called "Arc of the 30th Meridian"—and a meridional arc extending from Chile to Canada. These arcs were completed within the past three years and are the longest of their kind ever available—about 100 degrees in length. Based on an assumed flattening of 1/297, a value of 6,378,260 meters for the semi-major axis was derived. This is about 100 meters smaller than the semi-major axis of the International Ellipsoid and tends to corroborate other recent studies on the figure of the earth in this respect. The root-mean-square uncertainty of this value is about 100 meters, and is due primarily to an assumed uncertainty of ± 1 in the denominator of the flattening.

In the field of photogrammetry, Army Map Service has recently devised a system of aerotriangulation designed to overcome the problem of inadequate and poorly-distributed control. In those cases where is is possible to plan and establish the geodetic control for the aerotriangulation of a mapping project, the normal procedure is to adjust individually each photogrammetric extension. This procedure is sometimes impracticable, however, as circumstances frequently preclude the establishment of additional mapping control, and the existing control to which we are restricted normally has a random distribution. Where this condition exists, a homogeneous photogrammetric solution is accomplished for the area as a whole by successively joining adjacent extensions and finally adjusting the geometry of these data to the best mean fit of the existing geodetic control. Thus far, field checks of results achieved by this "area" method of triangulation indicate that accuracy requirements are being met.

Mapping in the United States seems to be in a relatively healthy state. Steady progress is being made. New techniques are being developed. Through close coordination, ideas are being shared and duplication of effort is eliminated.

Rear Admiral H. Arnold Karo*—I am glad to have this opportunity of commenting upon the fine record achieved by Colonel FitzGerald's Topographic Division of the Geological Survey in extending the large-scale topographic coverage of the United States. For the quarter century immediately preceding the stepped-up mapping program during the post-war period, little progress was apparent in extending the basic topographic map coverage. During this time we all kept pretty busy in the

* Director, U. S. Coast and Geodetic Survey. (Admiral Karo was unable to attend the session. In his absence, this discussion was read by Captain Charles Pierce, U. S. C. & G. S.)

mapping business, but year-after-year we continued to estimate adequate coverage at 25 percent. Now we have moved forward to 37 percent.

This new momentum is most encouraging to all of us on the occasion of these joint annual meetings of the two leading mapping societies. Colonel FitzGerald can be justly proud of the part his Division played in this achievement.

The new map coverage now being printed in an ever-increasing volume is an extremely important contribution toward improving the aeronautical charts of the United States. Our basic compilations for the sectional and WAC charts can be no better than the source material that we are able to obtain. Not only do we have the advantage of the large amount of new published coverage, but, through the excellent cooperation afforded the Coast and Geodetic Survey by the Geological Survey, we have at our disposal the field sheets for all of the new map compilations well in advance of the published sheets. These photographic prints of manuscripts include as many as 2,000 quadrangle areas. Now, through the courtesy of the Topographic Division of the Geological Survey, we are able to use this wealth of unpublished material perhaps a year or so before it would normally become available.

I should also like to join Colonel FitzGerald in paying tribute to the substantial progress being made by Army Map Service in producing the 1:250,000-scale maps of the United States. Our appreciation is expressed to Colonel Abell in extending to us the same cooperation relative to the 1:250,000-scale maps as the Geological Survey has done in the case of the large-scale quadrangles. We receive photographic prints of the medium-scale manuscripts which are immediately incorporated into the aeronautical charts. Cooperative arrangements of this kind result from the very close contacts that are maintained between the Federal mapping agencies.

The Coast and Geodetic Survey supports the national topographic mapping program, which Colonel FitzGerald has just discussed, with the establishment of the primary geodetic control networks of the United States. I would like to discuss briefly details of this phase of the national mapping program.

Our control activities have been going on since the time of Hassler, the first Superintendent of the Coast Survey. The Bureau had its beginning on 10 February 1807, when the Congress authorized President Jefferson to proceed with a "Survey of the Coast." Even at that early date, when the general art of surveying was relatively crude, the first head of the Bureau realized the magnitude of the job he was undertaking, and the first operation he undertook was the execution of a system of triangulation along the Atlantic coast. This early work developed into a rigid system of triangulation on which all detailed surveying operations thereafter undertaken could be controlled in accuracy and separate units could be accurately related to each other. That was the beginning of the control surveys in this country and from the very beginning all topographic and hydrographic work undertaken by the Coast Survey has been controlled by triangulation.

The results obtained even in the earliest days were of such a high degree of accuracy that they are included in the present-day networks. These resultant data were used in due time by the Geological Survey as the basic control for its topographic mapping and were, of course, used in other engineering operations. Now there is scarcely any engineering work needing accurate positions, distances, and azimuths that is not based on precise triangulation.

For many years the leveling and triangulation of the United States were extended at a very slow rate. This was due to a lack of demand for the data except for a few special purposes as the engineer and the public did not comprehend their value, even though not easily accessible. With the expansion, however, of the triangulation and leveling nets, demands for the results of the control surveys have increased rapidly.

The first important extension of the work occurred in 1871 with the measurement of a transcontinental arc of triangulation which would give an accurate connection between the Atlantic and Pacific coasts of the United States and provided data for a determination of the size and shape of the earth. A little later, when the Geological Survey was created and the need for topographic maps became pressing, the Coast Survey was charged with the execution of triangulation and leveling throughout the interior of the country, to serve the same purpose with respect to the topographic mapping program that they were already serving with respect to the nautical charting program. The significance of these continental surveys was recognized in 1878 when the name of the Bureau received its present designation of Coast and Geodetic Survey.

The triangulation and leveling networks of the country were necessarily accomplished on a piecemeal basis. Arcs and lines were extended along certain routes to meet special and local

needs. The plan of adjustment followed by all countries, including the United States, has consisted of first adjusting existing arcs and lines and then from time to time fitting in new work to the old. This plan worked satisfactorily until the nets became very much involved with many closed routes. Each piece of new work that closed a loop of triangulation or leveling had to take up all of the closing error of the loop. This resulted in excessive corrections being applied to the new arcs and lines. While this plan worked satisfactorily for sparsely spaced arcs of triangulation and lines of leveling, it did not work well for nets that had many closed loops.

In 1924 the Bureau devised a method for adjusting large networks of triangulation. The first big adjustment was begun of the western half of the triangulation net of the country in 1924. This work resulted in a new datum which became known as the 1927 Datum. Work was started immediately on the adjustment of the eastern half of the country which was an extension of the 1927 Datum. This phase was completed by the middle of 1932.

The Temple Act, already referred to by Colonel FitzGerald, was also significant in the geodetic control program of the Coast and Geodetic Survey. At that time the control-survey program contemplated by the Temple Act recognized the need of national first-order triangulation coverage so spaced that in general no point in the United States would be distant more than 50 miles from a permanently marked point whose latitude and longitude had been determined with first-order accuracy. Second-order control would be interspaced to reduce the distances to not more than 25 miles. Similar networks were envisioned by first- and second-order leveling, with benchmarks at frequent intervals along the lines run, with the whole so spaced that in general no point would be distant more than about 25 miles from a benchmark of accurately determined elevation above mean sea level. Present-day requirements of large-scale mapping have brought demands for much closer spacing of primary control.

Great strides have been made in the execution of geodetic work in the United States during the past several decades. Since World War II, major effort has been exerted in Alaska toward completing the arcs of triangulation required by the Department of Defense. Emphasis in the United States is being placed on survey control required for the Federal mapping program and in support of water resources programs.

I should like to mention the plane coordinate system which has been developed for each state to aid the local engineer or surveyor in using geodetic control data. Most of you are familiar with these systems wherein the latitudes and longitudes of geodetic control points are expressed in plane coordinates so that the local engineer or surveyor can compute local surveys as though made on a plane surface and at the same time is assured that they are coordinated with the Federal network of control surveys.

Control surveys must of necessity precede the basic topographic mapping program. We know that our programming would be more effective if we could project our work plan into the future by at least five and perhaps ten years. I realize that this is a matter to which we have all given careful attention. Colonel FitzGerald cannot, of course, foresee all of the requirements that will develop in the future for topographic mapping or the many readjustments that are imperative in his program to meet changing conditions. Implementation of the Water Resources Policy study by the President's Advisory Committee is bound to have considerable impact on both control surveys and topographic mapping.

Among the various applications of electronics for measuring distances and heights, mentioned by Colonel FitzGerald, is, of course, the geodimeter which is making valuable contributions in precise measurements, especially for base lines. Progress is being made in the development of a portable-type measuring device especially applicable for mapping control based on the principle of the geodimeter. This new light-weight instrument will be readily adaptable to field conditions. Furthermore, it will be suitable for daytime use, whereas our observations with the geodimeter are usually made at night. I believe that we will see substantial progress during the next few years in developing this type of instrumental equipment.

I also wish to mention the use of electronic computing equipment. We now have on order a new electronic computer which will greatly accelerate geodetic adjustments in the Coast and Geodetic Survey. This new piece of equipment will be in addition to the machines already in use in the Bureau. It affords an added advantage in the analytic solution of photogrammetric problems in our own topographic mapping program.

A Report on California's Cooperative Mapping Program

By TRACY L. ATHERTON

DIVISION OF WATER RESOURCES, DEPARTMENT OF PUBLIC WORKS,
STATE OF CALIFORNIA

AMERICANS got off to an early start in mapping California. Before the United States had publicly indicated any aspirations to acquire the territory, the Fremont Expedition carefully mapped portions of its route up the Colorado River and through the desert and mountains. No attempt had previously been made by the Spanish or Mexican inhabitants to prepare more than rough sketches of the coast and a few inland routes. The discovery of gold in the same year California became American territory brought an immediate influx of people. Through the late 1850's and for the next two decades, maps were pieced together from many sources—General Land Office surveys, special mapping by county surveyors, exploratory mapping by the State Mineralogist, and geologic, topographic, and route mapping by special Federal commissions.

In 1879 the U. S. Geological Survey was established to take over the mapping and geologic exploration duties in the Western States and Territories of the several independent Federal surveys. From that time until the turn of the century the Survey appeared to confine its activities in California to the production of one-degree quadrangles of the mountain and desert areas. Some of these are still used in certain remote regions of the State but soon will be retired by mile-to-the-inch mapping.

Cooperative topographic mapping began in 1903 when the State contributed $10,000 to the Federal topographic mapping program. From that time forward the State has annually appropriated funds to aid the topographic mapping in California by the U. S. Geological Survey. The maximum pre-World War II appropriation was some $59,000 in 1933. The average annual expenditure from 1903 to the close of the last war was slightly under $14,000. During these 42 years the principal parts of the Central Valley were mapped at two inches to the mile. These maps facilitated the study and development of irrigation in the Sacramento and San Joaquin Valleys. In 1933 the State proposed an acceleration of the mapping program and made $100,000 available for matching funds; however, at that particular time Federal appropriations for mapping were cut instead of increased, and the program was curtailed instead of enlarged.

In 1940 the California State Planning Board prepared an excellent review of the survey and mapping situation in the State and pointed out that "modern maps are technical tools essential to the efficient and economical operation of many governmental and private agencies" and that "nine major types of surveys and maps, now far from complete, require active, sustained support from the state." War in Europe, the threat of involvement of this country, and a shortage of manpower kept the program from getting started.

Two years later a Japanese submarine dropped a few shells into a California oil field, and the very same reason, the possibility of war, which nullified the appeal in 1940, sparked into action an all-Federal mapping program in early 1942. When it appeared that modern maps of California might be required for maneuvering of troops, private companies and several government departments were pressed into service to prepare maps rapidly by various photogrammetric processes. In this work some

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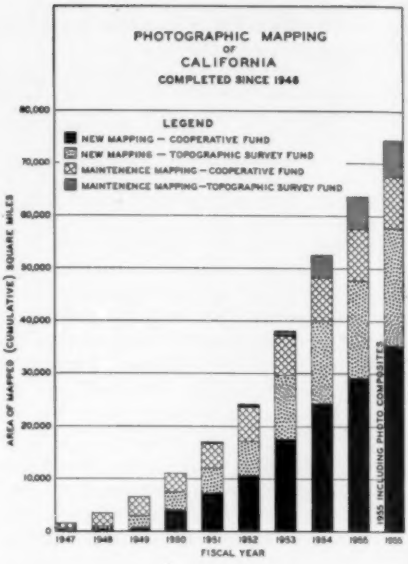
accuracy was sacrificed for speed, and these maps are generally of a lower standard than peacetime topographic mapping. Also many outdated 15-minte quadrangles were revised with the aid of aerial photographs and sketching devices, utilizing the contours and basic planimetry of the earlier U. S. Geological Survey planetable sheets.

AN ACCELERATED PROGRAM

In the latter years of World War II the California State Reconstruction and Reemployment Commission, acting through its Aerial Mapping Project Committee, thoroughly reviewed the topographic mapping situation in California and recommended to the Legislature "early completion of adequate basic maps to cover the entire area of California; maps to be made available through prompt publication; maps to be revised from time to time to keep abreast with the growth of the state." These suggestions were well received, and an expanded topographic mapping program was implemented by the Legislature in 1945 with, first, a biennial appropriation of $300,000, followed by annual appropriations of $300,000. Matching Federal money has been made available by Congress each year. The U. S. Geological Survey fully conducts the production of the maps—the State's interest is handled through a liaison office.

As can be seen on the chart, this accelerated program required several years before maps in numbers reached publication. It occasioned a sizeable and immediate expansion of the Pacific Region Office of the Geological Survey. With the advent of the Korean crisis the military requested and secured an increase in topographic survey funds. This has materially assisted the production of California maps and should be credited as being responsible for current attainment of the production goals set in 1945, offsetting the approximate doubling of salaries and wages which had occurred since the original estimate was made. Roughly 70 percent of the cost of a topographic map is labor cost.

Since the accelerated program began in 1945, there have been completed, as of last



June 30th, a toal of 868 quadrangles of which 541 were aided by funds supplied by the State. A total of 74,684 square miles of the State's 156,803 square miles, or 47.6 percent, has now been mapped since the war. The work already completed is equivalent to mapping the states of Indiana and Ohio. Now we have left an area about equal to Illinois and West Virginia combined.

The program is currently working on the tenth $300,000 State appropriation and by the end of this fiscal year the accelerated cooperative topographic mapping program will have cost the State and the Federal Government a total of six million dollars. This is about 50 cents per resident for the decade or approximately a nickel a year per person.

Remarking on this nominal cost, the head of a large cement company says: "Even with the advent of relatively cheap aerial surveys, the cost of complete mapping would be economically impossible for most industrial outfits."

The need for maps is universal. Maps are required for military operations, engineering enterprises, industrial development,

geological exploration, forestry, agriculture, and the conservation, utilization, and development of all natural resources.

DETERMINING MAP NEEDS

In order to determine if California's topographic mapping needs were being met by the quadrangles, the State Engineer sent out a questionnaire in January 1956 to 1,600 public officials, consulting engineers, mapsales agencies, engineering contractors, land surveyors, timber companies, oil operators, appraisers, and other categories.

To the fifty uses provided in the check list, correspondents added an additional twelve or fifteen—

A county assessor tells us: "Quadrangle maps are of particular value to us in developing information on future land use."

A farm advisor states: "Topographic maps are a must in any agricultural planning."

Another farm advisor says: "Many times we have used quadrangles for directing aerial pest-control work as the detail is so clear in them it assists greatly in directing pilots."

A Chamber of Commerce secretary says: "We find these maps very helpful for the use of prospective property owners; particularly those interested in industrial property."

A housing developer states: "We use these maps extensively in our subdivision work, both in land analysis and preliminary layout."

A large engineering contractor declares: "We often purchase U.S.G.S. maps as an aid in preparing bid estimates for construction work and occasionally on going jobs to locate access roads and lay out line and grade. We find the maps very useful, especially the later ones."

Another contractor says: "We use U. S. Geological Survey topographic maps for plant sites, quarry operations, and allied fields of construction."

And another contractor adds: "The importance of these maps cannot be over emphasized."

These are big firms that build our highways, breakwaters, dams, and bridges.

It was also noted that the same men indicated use of quadrangles for hunting and fishing. In fact, the best-selling quadrangles in California are recreation quadrangles—the Yosemite Valley and the Sequoia and King Canyon, each about 7,000 annually.

Two land surveyors say: "I use quads almost daily and am sure there is a great saving in money and time to myself and clients also."—"The great store of data on quad maps has been a continuing engineering cost saver for me."

And another adds: "U.S.G.S. quadrangles are essential to the operation of any surveying or engineering office. We have found the 7½-minute quadrangle valuable, and particularly useful."

A seismologist states: "We have a special interest in accurate mapping covering the San Andreas and other active faults; we believe that mapping in such areas is of special economic value to engineers, economic geologists, and others."

A town engineer says: "Such maps are vital to many public works projects and the cost to perform privately is out of question on small projects (sewers for a small town, for example)."

The engineer for a small irrigation district writes: "Quadrangle sheets forming a composite map of the central portion of El Dorado County, our particular area of interest, receive more use on a daily basis than almost any other maps which we have. Without this map we would be completely lost. We do not have funds to do the mapping necessary to replace it and therefore we would try to get along without it, but to attempt to do this would be like trying to work in the dark."

And the engineer for a larger district says: "We find these maps of considerable use; they save our taxpayers many dollars in surveys which we would otherwise have to make."

While most people want the latest sheets available, one city engineer says: "We have found *old* U.S.G.S. maps to be of considerable value as a record of natural waterways, swamps, etc., which have been par-

tially or wholly covered by recent improvements."

Earl M. Price and Co., which firm sells U.S.G.S. maps in Bakersfield has this to say: "Our views are the views of a company that sells a good many topographic maps at retail every year—not so much for the small profit in it as for the service it provides to customers who buy other products. We know that there is a large demand for these maps, and we keep on the shelf several copies of every topographic map we can lay hands on, covering any area in California, besides a small supply of areas in all states west of the Rocky Mountains. We are certain that the public makes a very great deal of use of these maps. We are enthusiastic, and perhaps zealous to a point where we might be thought biased. Topographic maps make intelligent planning possible at a negligible cost and cannot fail to contribute a great deal to the development of this State."

And here is the way a State Forester uses the maps: "Maps are a necessity in planning control efforts on large brush fires. It is by reading them that much of the determination of probable fire behavior and time element is arrived at. This in turn enables fire fighters to pick proper geographic positions to construct fire breaks. Maps are also used to show crew leaders how to reach an area and where to work. All County Headquarters and smaller unit stations must have maps by phones and in all vehicles."

Again let me quote: "The Sierra Club, Angeles Chapter, uses quadrangle maps for planning ski tours, knapsack trips, hiking trips, exploratory trips; and selecting boundaries of areas proposed for Wilderness or Wild Areas; for studying proposed boundary changes of Natural Forests, National Parks or Monuments, or State Parks. The maps are a valuable asset for those who wish to explore unfamiliar territory for recreation."

An engineer at Barstow, the largest town on the Mojave Desert, makes the following request: "Topographic maps are invaluable in the desert area. The only maps available are township maps, 100 years old in many areas. This office is continually visited by persons from Los Angeles wanting information on location of desert land. Where U.S.G.S. maps are available we can help and are able to do a public-relations job. Where no maps are available the persons leave thinking we or anyone else in Barstow wouldn't know our own fathers if we saw them. I certainly urge California to provide funds to continue the program to furnish more and more topographic maps."

And in the same area a title man says: "Many areas of San Benardino County not covered even by Bureau of Land Management surveys are in mining territory; mining work on records has increased over 1000% in the last few years."

A communications engineer uses quadrangle maps to eliminate dead spots in the State Highway Patrol radio net. He writes: "In connection with the radio field survey activities of the Communications Division, it is necessary to regularly employ topographical maps on a statewide basis. Heretofore, field actities have sometimes been handicapped by the lack of quadrangle sheets, particularly those pertaining to certain mountain and desert areas."

Lumbermen are quite interested in the topographic mapping program. One says: "We own 85,000 acres of timberlands which are being operated and developed on a 'sustained-yield' basis. Quadrangle maps are of great help."

Another gives a few more details: ". . . The purpose of this management is to maintain the full productivity of these forest lands and thereby insure the continuous flow of forest products to the nation's markets.

"Accurate topographic maps are an essential tool in this program.

"Our method of harvesting forest products requires the construction of an extensive system of high-grade truck roads. Topographic information is necessary in planning and locating these roads.

"The detection and location of forest fires, insect attacks, and windthrown timber are facilitated by good topographic maps.

"In fact, all phases of timber management from the planning of current and future operations to the maintaining of records of past activities requires the constant use of maps of all kinds."

Planning and preliminary design of any comprehensive water development is impractical without topographic maps. Only with the aid of full and complete hypsometric coverage can such a study become a sound engineering appraisal. In the absence of such maps the Metropolitan Water District, in the 1930's, was required to expend $750,000 to obtain 100-foot contours of the Mojave Desert for preliminary planning of the Colorado River Aqueduct. Even this large sum provided only single-use maps, unsatisfactory for publication because they did not require the culture data to meet more general needs.

Recently the California Division of Water Resources conducted a study for a proposed 350 second-foot diversion 110 miles in length over a pass in the Coast Range using copies of quadrangle manuscripts at a map cost of $1,200. The estimated survey saving on this one job was $55,000.

In 1940, the then State Engineer, Edward Hyatt, stated: "Existing topographic maps alone have saved the Division of Water Resources more than 2¼ millions."

Now that the Division's water studies have extended beyond the central valleys to the rougher north and north coastal areas and in the light of increasing salaries and more detailed studies, this figure can be multiplied.

The U. S. Bureau of Reclamation informs us that U.S.G.S. quadrangle sheets are extremely useful. If they were not available a considerable amount of surveying and mapping would be required before preliminary decisions could be made. As it is, many studies are completed with only the information obtained from these sheets.

F. V. Hollister, of the Union Oil Company, sums up in a few words the experience of many large corporations: "By usage of the new quadrangle sheets at a trifling cost, Union Oil Company saves unknown thousands of dollars each year."

The replies to our questionnaire of January 1956 are almost unanimously in approval of the current topographic mapping program, and the suggestions voiced generally had to do with supplying larger-scale maps of additional areas of the State. This has always been the trend and the program will certainly be gauged to the requirements. Mapping at the larger scale costs roughly 60 percent more per unit of area than mapping at the smaller scale. However, the smaller-scale map will prove to be an expensive expedient if within ten to fifteen years a larger-scale map will be required.

KEEPING MAPS CURRENT

Now, as was indicated above, the State of California is rapidly approaching a long-sought goal of full and current topographic coverage. However, before we reach the full coverage we will be obliged to enter upon a maintenance program to keep current some maps in metropolitan sections. Later, when the mapping of the State is complete, at least one-half of the present effort, on the present basis of planning, will be required to maintain them current. An outdated map is a source of misinformation.

In 1951, the State Engineer adopted a map detailing the State into four categories arbitrarily identified as Urban, Agricultural, and Pastoral, all of which were to be mapped at a scale of two thousand feet to the inch, and Rural, to be mapped at a scale of one mile to the inch. The appellations are generally representative of each section. The three divisions of the larger-scale mapping area are for the purpose of assigning rates for frequency of maintenance revision. The density of population is a general basic index of the rate at which a map will require maintenance revision.

The transportation nets in and around our cities are currently undergoing radical changes and are the principal reasons why the metropolitan quadrangles will require revision on at least an eight-year basis. Many other features such as land leveling and tract building influence large portions of a quadrangle. During the revision of one Los Angeles area quadrangle in 1953, changes were occurring at approximately the same rate as the field crew could discover and record them. A request to send in the field sheet on a specific date was required in order that the data assembled could be published.

The principal characteristic of the next group of maps is agriculture. In most of California this is synonymous with irrigation. Here the changes are less frequent than in the urban areas and for the present it would appear that the maintenance on a 15-year basis will suffice.

The third group of guadrangles at two thousand feet to the inch covers areas of the State which may be devoted to agriculture when water is available, routes considered for major aqueducts, and rural sections traversed by trunk highways. A nominal 25 years is assigned to the maintenance period for this group.

Some of the 1:24,000 mapping now in existence is not scheduled for maintenance at this scale. Included in this category is special-purpose mapping such as the 1948 base for geologic mapping in the Mother Lode country and various military ranges in the desert area. The contour data on these maps will change but little and will probably be as acceptable 50 years from now as at present. It would appear that the culture changes for a general-usage map can be adequately reported on the mile-to-the-inch compilations.

Most of the desert and mountainous areas of the State are currently being mapped at 1:62,500. These remote areas are but thinly populated and changes are not expected to be frequent. Consequently, a 25-year maintenance schedule has been adopted for this group.

The general distribution into the above categories was assigned from the best information available at the time the basic map was prepared. As the mapping of the State progresses a reappraisal is made each time a new project is added to the program. In some cases the scales are modified as a result of field inspection or on the basis of new general requirements.

Another facet of the picture is the series conversion of 7½-minute quadrangles into a 15-minute compilation as each four basic maps are available. Our first hope of full coverage at uniform scale lies in completion of the 15-minute series. To date a lack of adequate drafting capacity in the Pacific Region has held this program at a standstill during the last two years, but it must be resumed soon in order to clear up a rapidly accumulating backlog.

This brief review of California's experience in topographic mapping has attempted to point up the salient facts:

First—The road to a comprehensive and effective mapping program is sometimes long and difficult.

Second—The appreciation of quadrangle sheets is universal among many different categories of map users, establishing the fact that the sheets adequately fulfill the broad general requirements for basic mapping.

Third—Map maintenance, on an orderly but flexible plan, must be instituted early in the program to insure maximum efficiency.

The day which will mark the successful achievement of the basic goal of the expanded topographic mapping program is the day when a full and current 15-minute atlas of California, supplemented by a comprehensive coverage of the cities, irrigated areas, trunk highways and the littoral at two thousand feet to the inch, is available to the public—and that day is not too far in the future.

DISCUSSION

MR. WILLIAMS (Geological Survey): Is your distribution handled entirely through your office or do you have agencies scattered over the state?

MR. ATHERTON: We have made no attempt to distribute the maps through the State office other than to make available an index of topographic maps which are currently available for California. The free maps which are supplied by the Geological Survey to the State are distributed through our Department, but they amount to about 175 per sheet. The sales come through Denver, which is slightly inconvenient. Then we have two or three private outfits who supply maps in both Los Angeles and San Francisco, and they are pretty much on their toes, like the man I spoke about in Bakersfield. I list in our index each topographic map, and we list approximately 30 or 40 stationery stores that handle, not a full set of maps, but a large number of areas in which the customers seem to be interested.

Now Mr. Bechert indicated that map sales in Indiana were about 5,000. I think he has only scratched the surface. Sales in California to

private people range in the neighborhood of 250,000 at the present time, and one of our questions in the questionnaire was to this effect: How can we better get out information that maps are available? We received a great number of answers in connection with that. There was only one man that objected to mapping and you might be interested in that. We asked what could we do to increase the mapping and he said: "Don't do that. Stop making the maps. The Russians already know too much about California."

MR. COOK (Maryland National Capital Park and Planning Commission): Mr. Atherton, I don't believe this is a fair question, but in response to the questionnaire you speak of, I wonder what indication you got, particularly from urban areas, as to preference for larger-scale maps.

MR. ATHERTON: I don't believe that we received any suggestions for larger than the 2,000-feet-to-the-inch map. However, the areas covered in California may be a little greater than here. As it is, you couldn't hope to get the Los Angeles area on even a 15-minte sheet.

MR. COOK: That is true. But in smaller areas, such as some towns, we are thinking of trying to promote a map of 200 feet to the inch.

MR. ATHERTON: For other purposes, it is true, you may want larger-scale mapping of particular areas.

MR. COOK: This is for planning uses, but we are thinking of it on a county basis now, which, of course, might amount to as much as 500 square miles. The cost of the maps tends to scare everyone away, but we are working along that line.

MR. ATHERTON: We have had 1:24,000 sheets pieced together for Contra Costa County, and in Santa Cruz County I think they are preparing double-scale (that is, 1000-feet-to-the-inch) blow-ups of the maps as they are published. But for construction purposes—for instance, in connection with the Feather River project and the design of the canal—the Division of Water Resources contracted for 200 feet to the inch with five-foot contours for a considerable strip down through the State.

MR. COOK: We are thinking of some type of questionnaire along that line locally and I was wondering whether you got any indication from this one that some users would prefer to see more money spent for large-scale maps.

MR. ATHERTON: There may be a few that are quite vocal about that, but if you are going to map the whole area and need a map for this section, you would be better off at 1:24,000 with a double blow-up. If you get the large-scale map you have too much paper to handle for many operations. That, I believe, is something for local areas to develop for their local planning maps.

MR. WILLIAMS: Do you get any material that is on a scale larger than the 1:24,000 publication scale? That is, do you get preliminary material in larger scale?

MR. ATHERTON: I spoke of $55,000 approximately that was saved on one 110-mile pipeline job. That was with 20-foot contours; the manuscript had just been completed and it was blown up to 440 feet to the inch. As it was a line under pressure, we had a choice of a head of approximately three to four hundred feet, since it was pipe rather than canal. If it had been a canal, probably we would have needed a smaller contour interval than the 20-foot interval, which the sheets gave.

CHAIRMAN DRUHOT: Mr. Bechert, do you want to say anything about the number of maps that Mr. Atherton tells us they sell—250,000 a year? I don't believe the figure you mentioned can be compared to this—that is only from one place, isn't it?

MR. BECHERT (Indiana Department of Conservation): That's right. We do distribute maps and that is the total of our sales. Maps are distributed in Indiana by a couple of other map companies. Then, of course, many people write directly to Washington for maps, so the total must be considerably more. I was very much surprised by the tremendous sales in California.

Regarding this large-scale map business, there is some desire in Indiana in some of the smaller towns to have large-scale maps. This is not practical under our present program because of the increased cost. However, in one or two instances, the cities themselves have paid the difference in cost to map on a five-foot contour interval rather than the standard 10-foot interval. This helps considerably, especially if those maps are blown up. That might be one of the answers to your problem.

MR. COOK: The same scale?

MR. BECHERT: Yes, but they are maps with closer contour intervals and if you blow those up you do have a better map for planning needs.

MR. ATHERTON: I should add, on that 200 and some odd thousand, there are about a hundred that go to standard distribution.

CHAIRMAN DRUHOT: In addition to that?

MR. ATHERTON: Yes.

CHAIRMAN DRUHOT: That is certainly an enormous thing. I am certainly glad to hear about that questionnaire you sent out. We

looked it over pretty carefully, and we are in the market for such things, to find out how people are using the maps.

MR. BECHERT: I'd like to ask Mr. Atherton if he has any copies of that questionnaire with him.

MR. ATHERTON: Yes, I have. I might say another thing in this connection: The answers were unanimously in favor of the mapping program even when the individual answering was not a map user. And then we had other situations, such as when we circulated them to all the County Superintendents of Schools. We received answers from three or four stating that they used the maps to show the outlines of school districts; to shift the boundary of a school district; or for bus routes and so forth. We plan to write to the others in that group who can't seem to find any use for the maps and tell them what the few who have replied are doing with the maps. That is a way to increase the use of maps. We looked for a way to put maps into the schools, but we haven't solved that problem yet.

CHAIRMAN DRUHOT: Mr. Striker, I wonder if you could tell us, regarding this rather interesting matter of distribution, the number of maps published annually now and the number of copies?

MR. STRIKER (Geological Survey): I couldn't tell you the total number of copies, but we normally print about three or four thousand copies of each map for the first printing. That will vary depending upon what sales have been over the past several years in that particular area. We try to print, at first at least, a five-year supply and sometimes a ten-year supply, the best that we can calculate. We print about 1,500 new maps a year, plus about five to seven hundred reprints. Reprints are, of course, getting to be a bigger item all along. There are more new maps and, of course, there are more reprints needed too. But, as to the total number of copies—I haven't figured it out, but it is an astronomical number of printing-press impressions.

MR. MALTBY (Geological Survey): The number of maps printed by the Geological Survey is about 8 million per year.

MR. LYNN (Geological Survey): Annual *distribution* of maps is about four million.

CHAIRMAN DRUHOT: Are there any more questions? (No response.) Then we stand adjourned.

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Indiana's New Mapping Program

By CHARLES H. BECHERT

DIRECTOR, DIVISION OF WATER RESOURCES
INDIANA DEPARTMENT OF CONSERVATION

THE HISTORY of the topographic mapping of Indiana is not a laudable one and there might well be some question as to how the State has been developed as well as it has in the absence of adequate maps. It is only in the last few years that there has been a widespread demand for maps and that their true value has been realized by those responsible for providing the necessary funds to carry on an effective mapping program.

The earliest topographic mapping in Indiana apparently was done to complete quadrangles which extended into Indiana from adjoining states. This is particularly true in the southwestern part of the State, adjoining Kentucky and Illinois, taking in areas included in the coal-producing portions of the three states. Later, other areas of the coal basin, lying entirely within the State, were mapped, probably because of the needs of coal-producing interests.

The first quadrangle to be mapped in Indiana, the Calumet, Illinois-Indiana quadrangle, was completed in 1889. About eight years later the Danville, Indiana-Illinois quadrangle was mapped. Both of these maps were at a scale of 1:62,500 and comprised only 45 square miles of Indiana area. They were part of the Danville Folio, No. 67.

The Mount Carmel and New Harmony 15-minute quadrangles, which also contained portions of Illinois and Indiana, were mapped in 1901 and 1902. To these were added the Princeton and Haubstadt quadrangles, and all four were reduced to a scale of 1:125,000 to form the Patoka Geologic Folio—No. 105 in the U.S.G.S. series.

Other early mapping along the Kentucky-Illinois border consisted of the Tell City, St. Meinrad, Owensboro, Newbury, New Harmony, Mount Carmel, and Tolleston 15-minute quadrangles at a 1:62,500 scale and 20-foot contour interval.

All of this work was done between 1882, the time that the Topographic Branch of the U. S. Geological Survey had first been authorized, and June 1904. While many States such as New York, Pennsylvania, Ohio, Kentucky, and Illinois all have records of contributing funds for mapping during that period, there is no evidence of Indiana having participated in any of the above mapping on a cooperative basis.

As a matter of fact, the first known cash contribution was made during the fiscal year 1919–1920 by the State Geologist for control work on the Heltonville and Colitic quadrangles, which are located in the region where building limestone is quarried. He allotted $1,323.40 from his funds for this work.

All of the quadrangles which were surveyed and published prior to 1919, were handled solely with U. S. Geological Survey funds. This includes parts or all of about 25 15-minute quadrangles.

MAPPING LEGISLATION

As early as 1923, the Assistant State Engineer of the Department of Conservation directed his efforts toward the passage of legislation to establish a mapping program in the State. A mapping bill was introduced in almost every session of the legislature from 1923 until 1937 when such a program was finally established. The disastrous flood of 1936–1937 undoubtedly was a deciding factor in getting favorable action on the bill in the final days of the 80th session of the General Assembly. The law as passed called for an annual appropriation of $25,000 for a ten year period commencing July 1, 1937. The Department then entered into

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a cooperative agreement with the U. S. Geological Survey for a State mapping program, and, after holding conferences with various engineers of the State who were interested in having the State mapped topographically, a scale of 1:24,000 was decided upon at that time as being the best and most practical scale. A 10-foot contour interval was adopted as "standard" for the State.

The above program continued on the same basis until 1945 at which time an additional $50,000 for mapping was secured in the Department of Conservation's biennium budget for 1945–1947. The increased appropriation was obtained chiefly because of the rise in the cost of mapping and the need for additional funds to maintain the program on a production basis of the kind envisioned when the program was initiated. In the following session of the legislature, the original mapping law was repealed and another passed which increased the annual appropriation to $50,000 for another 10-year period beginning July 1, 1947. The new law created a rotary fund so that none of the annual appropriation would revert to the State general fund until the topographic mapping program was completed or until obsolete or inadequate maps were revised.

STATE AGENCIES NEED MAPS

In 1945 the Department of Conservation created a new division within the Department, not only to direct the State's interest in the mapping program, but also to execute a statewide investigative program of Indiana's water resources, as specifically authorized by the legislature in 1943. A new State department was also created in 1945 which is known as the Indiana Flood Control and Water Resources Commission. This commission is charged with the responsibility of developing a master plan of flood control and water resources for the State.

As the work of these two departments progressed, it soon became evident that they were greatly handicapped by the lack of adequate maps. The Water Resources Division, in cooperation with the Water Resources Branch of the U. S. Geological Survey, was making detailed ground water studies in several sections of the State. These studies were being made on a county basis and, in all of these early investigations, there was not a single area that had been mapped. A large percentage of Indiana is glaciated, and the most prolific ground water supplies are found in the glacial materials. In ground water studies of such areas, it is essential to know the thickness of the glacial drift and also the contour of the underlying bedrock in order to delineate buried channels and other geologic features having a bearing on the water resources. As topographic maps of the areas were not available, it was necessary either to make an incomplete study of the area or to map the area. Since it was impossible to do any extensive mapping under the water program, it was necessary to make generalized maps of the area with the use of altimeters. Needless to say, this was not and is not a satisfactory solution to the problem.

The Food Control and Water Resources Commission met with similar experience. Much of their work was being done in cooperation with the U.S. Corps of Engineers in making studies of potential sites for flood control reservoirs. Here again, they could do little in determining the feasibilty of any site without topographic maps. Reliable maps were of the utmost importance to their work, and it was necessary for them to map most of the valleys where they were making detailed studies. This was not only expensive but time-consuming as well. Their work would have advanced much beyond its present stage had topographic maps of the State been available when the agency was created.

Shortly after the war, the Indiana Economic Council, another State agency, began to expand its activities in the field of community planning. Enabling legislation, enacted prior to that time, provided the machinery for the creation of City and County Planning Commissions. The Economic Council, not only sponsored the formation of such Commissions, but gave some assistance in the over-all problems of planning the future development of various towns and counties in the State. Again, as with other State agencies, the lack of adequate maps

was a deterring factor in the progress of this program.

During the same period, an accelerated program of steam pollution abatement was being pushed by the Stream Pollution Control Board and the State Board of Health. While topographic maps were not as essential in the program of building municipal and industrial sewage treatment plants, nevertheless maps of this type were becoming increasingly more important to the Board of Health in its many diversified activities of water supply and sanitation.

The State Geological Survey, which has grown in the last ten years from a relatively small organization to one which is recognized as among the best, is in need of maps as much as, if not more than, any other State organization.

The State Highway Department, like the many other State agencies, had to plan its expanding road-building program without the aid of contour maps, and it, too, experienced the same difficulties.

MAPS ESSENTIAL FOR INDUSTRIAL DEVELOPMENT

Not only did the State Government expand its functions after the war, but, as in the case of many States, there has been a tremendous expansion in industrial development. Today Indiana has 30 percent more industries than in 1940, and the number of employed people has doubled in that time. Bringing about such an industrial growth entails the building of many new factories and the establishment of new industrial concerns. To suply these with power, fuel, and water; new power, gas, oil, and water lines have to be constructed. A 230,000-volt transmission line has been built from Terre Haute to Kokomo, a distance of some 100 miles. Another high-voltage line has been constructed from Lawrenceburg to Ft. Wayne, a distance of 130 miles, and still another from Terre Haute to Columbus, a distance of 80 miles, to mention only a few. Several oil and gas lines have been laid across the State and many more for shorter distances. In each case, the power companies and the oil companies have made use of whatever topographic maps were available in the planning of these projects and have felt the need for a wider coverage of maps as much as anyone.

With the building of several new power plants along the Ohio River and elsewhere in Indiana, the coal industry has been greatly expanded, especially those companies engaged in strip mining. These companies have made extensive use of existing maps but, as in all other instances, too few are available.

The railroads have been actively engaged for the past ten years in acquiring and locating industrial sites for new factories along their railroads, and they, too, have been clamoring for more and better maps.

The stone industry, the tile manufacturers, and the gravel companies have all been interested in locating new sources of raw materials because of the tremendous increase in the demand for their products. The lack of topographic maps has been of more than passing concern in recent years to the leaders of these industries.

So great did the demand for topographic maps become by 1951, not only by governmental agencies, but by industry as well, that a meeting of the Indiana Economic Council was called to discuss the problem while the legislature was in session that year. This meeting was attended by representatives of the railroads, utilities, coal industry, well drillers, residential builders, consulting engineers, county surveyors, and various State departments. As a result of this meeting, an attempt was made to get the legislature to increase the mapping appropriation, but because of the demand from all over the State for an increase in funds to raise the salaries of teachers, most other measures calling for increased appropriations received little consideration. Because a similar situation prevailed in 1953, no concentrated effort was made to expand the mapping program that year.

However, the interest in mapping continued to grow. This is evidenced partially by the number of maps which were sold by the Department during that time. From 1949, when the first accurate records of sales were kept, the sale of maps increased

from 2,944 during that year to 5,792 during the last fiscal year.

In the early part of 1954, it was suggested that another meeting of map users be called to discuss the mapping situation again. At the rate the State was being mapped it would require almost forty years to finish the mapping. There are a total of 691 7½-minute full or partial quadrangles in Indiana and only 245 quadrangles had been covered with modern maps at that time, or approximately 34 percent of the State.

In April of 1954, a meeting was called by the Department of Conservation to which were invited representatives of State agencies and industrial interests who attended the 1951 meeting and also many other map users. This group felt that it was vital that the State mapping program be materially speeded up and that the State should be completely mapped in a period of about ten years. As one individual stated: "Future developments are now being considered by my company and many other companies are doing the same. Maps are needed now and not thirty or forty years from now. If the mapping program is not completed within ten years there is not much use in continuing it, as far as I am concerned."

As a result of this meeting, a committee was formed under the chairmanship of a representative of a local, private, power company. The committee was formed to educate some of the legislators, the majority of whom are farmers, regarding the urgent need of an accelerated mapping program.

INDIANA RECOGNIZES MAP NEEDS

Rather than seek special legislation for increased appropriations for mapping, the Conservation Department increased its budget request for mapping from $100,000 for the biennium to $400,000. Later, during the legislative session, in explaining to the budget committee the Department's request for increased funds for mapping, the chairman of that committee commented that they had received more comment on the need for increasing the mapping program than on any other item.

In 1953 the legislature established a Study Commission on Intergovernmental Relations, which covered such subjects as agriculture, education, welfare, conservation, institutions, fiscal administration, and so on. The recommendations of this Commission, which sumbitted its report to the General Assembly in 1955, are also of interest, especially the following extract:

"The Commission recommends that the topographic mapping program be accelerated and completed within a period of five years. This will involve a cost to the State of Indiana of approximately $400,000 per year for a period of five years. The Commission believes that topographic maps provide valuable information for the State and Local Governments and for Indiana businesses as well. They have an eminently practical use in solving problems touching on water resources, flood control and conservation, real estate developments, construction projects, and in many other situations."

While the recommendations of this committee called for a program double that which was asked for by the Department and approved by the legislature, it undoubtedly was effective, as were the efforts of the mapping committee, in obtaining the favorable action taken by the General Assembly.

Following the adjournment of the legislature, an invitation was sent to representatives of various interests in this type of mapping, asking that lists be submitted showing preference of the areas they would like to have mapped. When these lists were returned they were used as guides in compiling a priority schedule of all unmapped quadrangles. Each State Representative and Senator was also invited to designate any areas in his district or area which, because of some special problem, should be given consideration for early mapping. One interesting reply to this invitation is as follows:

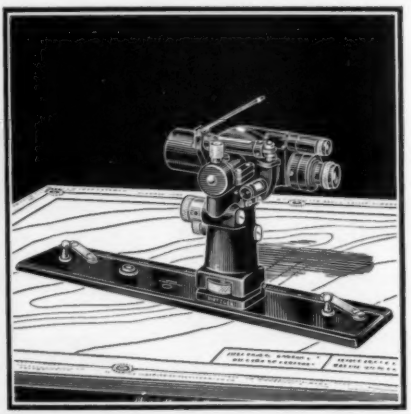
"I was not in favor of the $200,000 appropriation at the time we were acting on it, because I did not understand the need for same. Too, those in this part of the State are usually last to be considered in such matters if at all. Your letter and my talks with the professional engineers here prove my having been wrong on both instances.

I find that my county and other neighboring counties are very much in need of topographic maps."

The expanded program is now in effect and, while the legislature made no commitments beyond the biennium, there is good reason to believe that topographic mapping in Indiana will be continued, at least at its present level. Such was the understanding when the matter was being considered. Along with the mapping program, a maintenance program has been set up to keep the older maps up to date. About 2 percent of the funds will be spent for this purpose.

Since the accelerated program has been in effect, the interest in mapping has become even greater; new map users are continually showing up, as well as new uses for the maps. Whereas maps previously were ordered in single copies, they are now being ordered in quantity, something which is difficult to explain. Requests for maps of unmapped areas have risen several fold, and only recently 51 separate requests were made for the early mapping of an area in the western part of the State. Greater use is being made of planimetric bases and blue line copies of maps, to say nothing of the increased use of and interest in the large-scale compilations. County surveyors and engineers are showing more interest in the maps than ever before and are making greater use of the Government's horizontal and vertical control. They are also showing more interest in the plane-coordinate system.

Indiana has waited a long time—much too long in fact—to establish an adequate mapping program. However, it is almost needless to say that the new program will mean an ultimate saving of millions of dollars to the taxpayers and business interests of the State. The maps will provide the tool needed in planning more efficiently the development of the State's resources and industrial wealth and will certainly pay great dividends in the years ahead.



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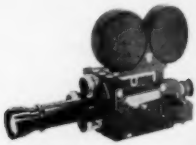

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Tacheometric Surveying

Methods and Instruments

Part II—The Subtense Method

By WILLIAM MUSSETTER
ARMY MAP SERVICE

THE FIRST installment of this article, published in the April–June 1956 issue of SURVEYING AND MAPPING, was confined to those methods which established a parallactic angle within the instrument. All such methods require the reading of a scale of some form at a distance and are subject to the difficulties of seeing the rod divisions distinctly.

This installment will cover the types of tacheometric measurements in which the reverse is the case, i.e., the angle lying opposite a fixed base is measured by the instrument. This angle is said to be *subtended* by the base, hence, the accepted name, "Subtense," applying to this operation. It applies particularly to the case in which the horizontal angle subtended by a fixed-length base bar, oriented at right angles to the line of sight, is measured on the circle of a theodolite. The angle may also be measured by means of a micrometer tangent screw actuating the horizontal motion of the instrument or by a micrometer placed in the focal plane of the telescope.

The ability of the observer to bisect the base-line targets is superior to his ability to read a graduated staff under ordinary conditions. Repeated pointings may be made for increasing the accuracy. For these reasons, the subtense method can yield better results than any of the intercept methods, provided proper equipment is used.

The instruments required for the true subtense measurement are a transit or theodolite capable of reading angles to the desired accuracy, and a base bar or staff. If the theodolite measures the angle directly on its limb, a finely and accurately graduated circle and circle-reading micrometer are necessary. Circles with coarser divisions and verniers may be utilized by the method of repetitions, provided the other parts of the instrument are in keeping with the final result required. Angular errors in the order of a very few seconds of arc must not be exceeded. The arc of 1″ is but 0.00001 part of an inch or one-fourth micron on the circumference of a 4-inch circle. This accuracy must be maintained by the fit of the centers and the rigidity of the mount.

FIGURE 1.—Subtense bar

The standard subtense bar is two meters long and consists of a metal tube supporting two targets near its ends. The interval between the targets is controlled by an invar wire which is placed under tension by springs, the targets being free to move longitudinally in the tube. Thus, the base length depends on the invar wire and is unaffected by temperature changes in the other parts.

A small telescope is attached at right angles to the bar for orienting it with the line of sight, and there is also a collimating device to enable the observer to verify the perpendicularity from the instrument position. A spirit level is provided for making the bar horizontal, and a central target serves for pointings in azimuth. The whole

bar is mounted on a tripod by means of a leveling head and spindle with clamp and tangent screw. The tripod is generally made interchangeable with that of the instrument, and often the leveling head as well. This permits placing the theodolite on the subtense bar tripod as work moves forward, eliminating the time and error of centering.

The targets are small triangles or diamonds on a contrasting background, with small points or circles marking the exact center. They may be provided with electrical illumination for night work, the light showing through small holes concentric with the targets. Different types or sizes of targets for use at different distances are sometimes provided on other faces of the bar and brought into play by revolving it.

Bars of 1 meter and 3 meters of this type are also available. The invar bars either fold at a joint in the middle, or the tubes may be detached from the head by means of screws or bayonet joints for transport. Staffs of wood or metal of various designs may be employed for work of a lower order. The advantages of these lower order bars over the more convenient intercept methods are doubtful.

ANGLES MEASURED DIRECTLY ON THE CIRCLE OF THE INSTRUMENT

The direction method is preferred for this type of measurement because of its simplicity, speed, and opportunity for judging the accuracy by the agreement of the independent measurements. However, this method requires a higher class of instrument. The method of repetitions may be employed with any high-grade transit. This may be of advantage for occasional work when it is not advisable to provide special equipment.

The direction-type instruments preferred for subtense have finely divided circles on glass, and read usually to single seconds. This class of theodolites is designated by European manufacturers by the number 2, and by reason of standardization and mass production, has practically taken over the subtense field. Some of the makers claim that an experienced observer can maintain an accuracy of from 1″ to 2″ by a single direct and reversed measurement of the angle. This probably assumes ideal conditions, for experience has shown that it is not easy to secure such accuracies in the field. Much has been done toward analyzing the accuracy of a pointing, but so many variables enter that little value can be placed on a purely mathematical approach. Under reasonably good conditions and using a 1″ theodolite, it is believed that a probable error between 1″ and 2″ can be obtained by four measurements of the angle. Nothing appears to be gained by reversing the telescope between observations because the targets are in the same horizontal plane. It is recommended that four measurements be made with the circle shifted through approximately 45° after each. This should require from 3 to 5 minutes for the pointings and readings. The agreement of the resulting measurements will indicate their accuracy to some degree. Depending on the circumstances, more or fewer observations may be necessary.

It must be remembered that the direction method assumes the circle to be fixed in azimuth during the pointings on the two targets. Any change due to lost motion or elastic recovery in the instrument or tripod, or to shifting of the observer's weight on the ground will introduce an error. This error may be systematic and undetected by the comparison of the independent measurements. It is believed this source of error is largely responsible for disappointing results reported from some trials.

An analysis of results obtained in Norway, and in a test by the Army Map Service with direction theodolites under average field conditions will be presented later in this article.

The method of repetitions is subject to the same uncertainty from any movement of the instrument in azimuth while the upper motion is unclamped. For the assumed precision, six direct and six reversed repetitions with a 10″ vernier theodolite are recommended. The reversed postion is recommended for reasons of reversal of motions in the instrument, rather than from considerations of the line of collimation. It is not believed that angular measurements in the

order of an accuracy of 2″ can be obtained with the ordinary surveyor's transit reading to 1 minute. Such instruments should not be used on work where the ultimate in accuracy is expected.

Observations by the method of repetitions are much slower and more laborious than those with a suitable direction theodolite. A set of six direct and six reversed repetitions between the two targets should take from 6 to 8 minutes of time.

THE MICROMETER TANGENT SCREW

The micrometer tangent screw, or subtense screw, is another device for accurately measuring the subtense angle, although not so well known as the measurement by circle as above. The micrometer screw is of particular interest as as accessory to a transit having an ordinary graduated circle. Since topographic work seldom requires a finely divided circle for other purposes than measurement of the subtense angle, such a combination is an economy. The instrument centers and telescope, however, should be equal to the demands.

The total angle that can be measured by the available screws is about eight degrees. This permits a *minimum* distance measurement of about 15 meters, using a 2-meter bar, which should be adequate for most all occasions.

As manufactured, the subtense screw is simply a fine-pitched and accurate tangent screw, carrying a divided drum, and substituted for the conventional tangent screw. The pitch of the thread is a decimal fraction of the lever arm against which the screw works. This fraction is usually 1/200 part of the lever arm. The drum is divided into 100 parts, so that the movement of the screw through one drum division corresponds to an angle whose tangent is 1/20,000 (0.00005).

Figure 2 illustrates the principle of the tangent micrometer. By similar triangles,

$$nd : h = \tfrac{1}{2}b : s$$

When d/h is made equal to 1/20,000,

$$s = 10{,}000\, b/n$$

n being the number of drum divisions turned from the mid-point of the bar to a target; b, the length of the bar; and d/h, the ratio of the pitch to the lever arm.

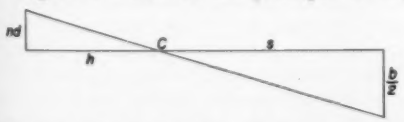

FIGURE 2.—Principle of the tangent micrometer

The micrometer screw is designed to be read both ways from its zero or mid-position, and the observation is performed as follows:

The micrometer screw is set to its zero or mid-position by means of the drum and scale, and the telescope is directed at the center mark of the subtense bar. With the clamps tightened, the line of sight is brought to one of the targets by turning the subtense screw, and the total number of drum divisions is read. The line of sight is then brought to the other target, using the screw alone, and the divisions read. The total angle in terms of drum divisions is equal to the sum of the two readings, n and n'.

The length, s, may then be found by the equation

$$s = 20{,}000\, b/(n + n'), \text{ or}$$

$$s = 10{,}000\, b/\tfrac{1}{2}(n + n'). \qquad (1)$$

The known instruments with this attachment have no other way of fine pointing than by use of the micrometer screw. Hence, the zero setting of the drum will be disturbed when the pointing on the mid-mark of the bar is made. This alters the values of n and n', but not their sum, and no error is introduced provided the screw defines tangents uniformly throughout its length.

The design of the reading mechanism is

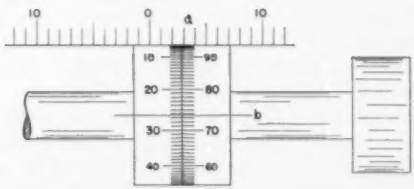

FIGURE 3.—Diagram of drum and scale, subtense screw

essentially as shown in figure 3. The drum is divided by a line engraved about its circumference, this line serving as the pointer for reading the turns scale, *a*. The drum is divided into 100 parts as shown, the graduations on opposite sides of the dividing line being numbered in opposite directions. The turns scale is figured outward in both directions from its index. The index line, *b*, engraved on the cover glass, serves for reading the drum. The part of the turns scale to the right of its zero is used in conjunction with the graduations on the right-hand face of the drum, and, similarly, left with left. The whole mechanism is placed under a magnifying glass to facilitate reading.

The anular value of one division of a 1/20,000 screw is approximately 10.3″. Hence, the readings must be accurate to about 0.1 division to give the probable errors assumed in Table 1. The probable error of the sum, $n+n'$, will be $\sqrt{2}$ times the probable error of either, so that the probable error in reading the drum must be held to between 0.05 and 0.1 division to be comparable with a probable error of 1″ in the angle read on the circle. The pitch of the screw, based on a lever arm of 4 inches, will be 50 threads to the inch. There is no design problem to prevent this being made 100 threads per inch, in which case the sensitivity of the micrometer would be doubled. An increase in the drum diameter and in the power of the magnifier would also make estimation of the fractional division more certain. On the other hand, a screw of finer pitch will be more tedious to handle. The 1/20,000 screw appears to be a good compromise and sufficient for topographic work. The drawback of the fine thread when used for azimuth pointings might be overcome by adding a second upper motion clamp and tangent screw of conventional design for all uses other than subtense measurements.

The original micrometer tangent screw designed by Pulfrich had a very sharp point bearing on a plane surface which lay in a radius of the graduated circle. If this contact is a true mathematical point, then the linear motion of the screw will define tangents of the angle of rotation. However, it is not possible to make such a contact, or to protect it, if it were. Hence, there is a certain approximation in the working of a screw of this type.

The point of the screw is in fact spherical. Referring to figure 4, which shows the effect

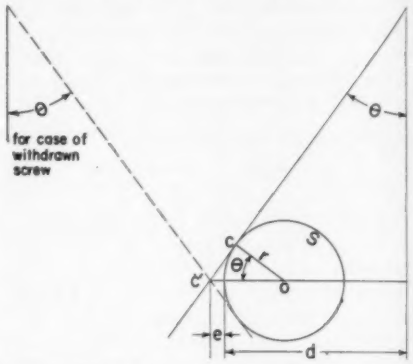

FIGURE 4.—Effect of spherical point on tangent screw

of a spherical surface bearing against a plane, it will be seen that, as the lever arm (plane) is brought to the angle, θ, from its mid-position, the contact, *c*, between the plane and the screw point, *S*, remains tangent to the surface of *S*. The linear travel of the screw is shown by *d*, while the tangent of θ is measured by $d+e$. Denoting the radius of the sphere by r, then $oc' = r \sec \theta$, and $e = oc' - r$, that is, $e = r \operatorname{exsec} \theta$. Therefore the linear error, *e* is proportional to the radius of the screw point and to the external secant of θ.

It appears that a radius of 0.25 mm. for the point would be suitable and durable. Assuming a lever arm of 100 mm. (4 inches), a base of two meters and $r = 0.25$ mm., at a distance of 10 meters the angular error introduced by *e* will be 2.5″. At 80 meters, it becomes negligible. In the case of the screw pushing the lever from its central position, the angle turned will be greater than that indicated by the reading. When the screw is withdrawn, the lever following from its mid-position, the error has the opposite sign. Hence, if the angle is measured approximately equally to the right and left of the central position, the error in

$n + n'$, is rendered negligible. This simple screw is therefore suitable for subtense work.

Another form of screw is shown in figure 5. This is known as the sine screw because the value, nd/h, is the sine of the central angle. The distance found from equation (1) would therefore be from the instrument to the ends of the subtense bar, rather than to its center. The screw, *S*, is fixed so that it does not move longitudinally when turned, but imparts a movement to the sleeve nut,

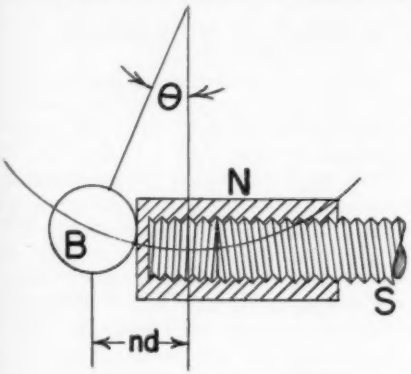

FIGURE 5.—The sine screw

N, which is restrained from turning. This nut has a ground plane surface which bears against a ball, *B*, on the lever arm.

This type screw is more complicated and expensive to make than the simple tangent screw, but can be made more rugged and durable. The distance may be calculated by trigonometrical formula, or taken from a table prepared for the instrument, as is also customary in the case of the tangent screw. It is, of course, free from any approximation in the measured sines. The reading mechanism of the sine screw is identical in principle to that of the tangent screw.

Both types of screws permit the repetition of readings to increase their accuracy. If the instrument is assumed to be rigid, the telescope need not be traversed from one target to the other for each pair of readings, but all bisections and readings may be made on one tangent, the line of sight traversed and all readings taken on the other. Naturally, the subtense screw simply measures angles, and all considerations of stability of the instrument apply to this as well as to the preceding method.

Both the foregoing methods, which measure the angle by rotation of the alidade, are free from any additive constants due to the optics of the telescope. Since the angles are measured in a horizontal plane, horizontal distances are derived directly. Differences in elevation are, of course, the horizontal distance multiplied by the tangent of the angle of inclination.

THE EYEPIECE MICROMETER

This type of micrometer has been put to very little use in tacheometry. The U. S. Geological Survey has applied the device to a plane table alidade[1] and used it for rough topography. Also, there are some references to it in European literature. In spite of its lack of application to surveying operations, the eyepiece micrometer has some merits worthy of mention. It is well known to astronomers and is one of the most convenient and accurate devices for measuring angles between objects lying within the telescopic field of view.

In its usual form the micrometer consists of a movable thread placed in the focal plane of the objective. The movement of the thread is measured by a fine screw with scales for indicating turns and drum divisions. Since the image of the distance to be measured is greatly reduced in size, the accurate measurement of angles imposes the highest grade of precision in the manufacture of the micrometer. Perhaps this is the chief reason for its failure to receive acceptance in the tacheometric field.

The principle of the eyepiece micrometer is the same as that of the fixed stadia threads except that the angle subtended by a fixed base is measured rather than a rod intercept. The anallatic properties of the telescope apply in the same manner. Either a horizontal or a vertical rod may be used.

The special advantages of the ocular micrometer are that the instrument remains

[1] *See* Topographical Instructions of the U. S. Geological Survey, page 210.

clamped in position with no mechanical motions other than that of the micrometer slide; the observations are made very rapidly with a high degree of accuracy; and the micrometer is very small, light in weight, and does not interfere with other functions of the teleescope. Its disadvantages are that the angle is limited to a portion of the field of view, probably to a maximum value of about one degree, and the rays utilized pass through the outer zones of the objective glass. The two combine to require a large aperture and well corrected lens. The parts of the instrument other than the telescope may be mediocre without harming the accuracy of the distances.

If the maximum angle it is possible to measure is one degree, the minimum distance to a 2-meter bar will be about 114 meters. Hence, additional marks at closer intervals would be required for shorter sights.

Due to the facility with which readings can be made, the number of readings may be multiplied to increase the accuracy. It has been suggested that ten bisections of each target be taken; first 5 in succession on one target, then 10 on the other, and finally 5 on the first target. This division of pointings will correct for a systematic twist in azimuth of the instrument during the observations provided the pointings are made at a regular rate of speed. The two columns of readings are meaned by decimal division. The micrometer can read continuously from one end, or in opposite directions from a mid-point. In the one case, the angle in drum divisions is given by subtracting the means, in the other by adding. The distance is then taken from a table prepared for this particular instrument and rod. This table may include any calibration corrections necessary for the instrument or rod.

Experiments with the eyepiece micrometer applied to large theodolites indicate a probable error in the measurement of the angle in the order of 1″. This high accuracy increases the certainty of the range at a given distance. The eyepiece micrometer is therefore fitted to work where consistently long sights are desirable. However, because of the limit to the size of the measured angle and the consequent large ratio of the measured length to the base, only moderate accuracy can be expected.

FIGURE 6.—The subtense triangle

THEORY OF THE SUBTENSE MEASUREMENT

Subtense is a form of triangulation utilizing a very small angle opposite a base which is placed perpendicular to the line whose length is to be measured.

Figure 6 is a diagram of the subtense triangle. The elements are the known base length, b, the measured angle, a, and the desired distance, s. The base is oriented so as to be perpendicular to the line of sight at its mid-point. It is readily seen that,

$$s = \tfrac{1}{2}b(\cot \tfrac{1}{2}a) \qquad (2)$$

or very nearly,

$$s = b \cot a \qquad (3)$$

The length is great in respect to the base; hence, a small variation in the base, b, or in the angle, a, will have a relatively large effect on s. This may be analyzed as follows.

Taking the partial derivatives of s with respect to b and a, from equation (2),

$$ds = \cot \frac{a}{2}\, d\frac{b}{2} - \frac{b}{2 \sin^2 \frac{a}{2}}\, d\frac{a}{2}$$

From figure 7,

$$\cot \frac{a}{2} = \frac{2s}{b}$$

and,

$$\sin \frac{a}{2} = \frac{\frac{b}{2}}{\sqrt{s^2 + \left(\frac{b}{2}\right)^2}}$$

$$\sin^2 \frac{a}{2} = \frac{b^2}{4s^2 + b^2}$$

Therefore,

$$ds = \frac{s}{b} 2d\frac{b}{2} - \frac{4s^2 + b^2}{2b} d\frac{a}{2} \qquad (4)$$

This equation expresses the change in s for given changes in b and a.

In order to state these changes for the general case in terms of the probable errors, we can replace $d\frac{b}{2}$ by the probable error e_{l_b}; and $d\frac{a}{2}$ by e_{l_a} arc 1″. The term, arc 1″, is necessary when the angular probable error is stated in seconds of arc. Its value in radians is 0.00000485. Then,

$$e_s = \frac{s}{b}\sqrt{4e_{l_b}^2 + \frac{(4s^2 + b^2)^2}{4s^2}(0.00000485\, e_{l_a})^2} \qquad (5)$$

The probable error of the base, e_b, will include any error in the base bar itself, changes due to temperature, and errors in leveling and aligning the bar perpendicular to the line of sight. If a well manufactured invar bar is used, and proper care is taken with the orientation, these errors will be very small. Generally, the base is assumed to be perfect and the whole error in s to be due to the error in a. A further approximation may be made on the assumption that b^2 is small in relation to s^2, and may be ignored. Discarding the terms e_b and b^2, in equation (5), we have

$$e_s = \frac{s^2}{b} 0.00000485\, e_a \qquad (6)$$

The proportional probable error is derived by dividing this quantity by the length s, or

$$\frac{e_s}{s} = \frac{s}{b} 0.00000485\, e_a \qquad (7)$$

Now $\frac{s}{b}$ is negligibly different from $\cot a$, and arc 1″ is equivalent to $\tan 1''$. Therefore,

$$\frac{e_s}{s} \approx \frac{\tan 1''}{\tan a} e_a \approx \frac{e_a}{a''} \qquad (8)$$

This is equivalent to saying the proportional probable error in the distance is equal to the probable error of the angle in seconds divided by the number of seconds in the angle. This rule is stated in many text books and is generally accepted by surveyors.

Assuming a base bar of two meters with a probable error of 0.1 mm., and a probable error in the measured angle of 1″, the probable errors for different distances are found to be as given in Table 1. The two columns of e_s furnish a comparison of the values as computed by equations (5) and (6).

TABLE 1[2]

S (m.)	$e_s(5)$ (mm.)	$e_s(6)$ (mm.)	$\frac{e_s}{s}(5)$
10	0.55	0.24	1/18180
20	1.40	0.97	1/14280
30	2.6	2.2	1/11540
40	4.4	3.9	1/9090
50	6.5	6.1	1/7690
60	9.2	8.7	1/6520
80	16.0	15.6	1/5000
100	24.8	24.2	1/4030
120	35.4	34.9	1/3390
140	48.0	47.5	1/2920
160	62.6	62.0	1/2550
180	79.1	78.6	1/2280
200	97.5	97.0	1/2050
400	388.5	388.0	1/1030

This comparison justifies the use of the approximate formula in all normal cases. Reference to the exact formula is necessary only in case the base is subject to unusual error.

Equation (6) shows the linear error to be expected from a given accuracy of angle measurement varies directly with the square of the distance, and inversely with the length of the base. The proportional error, equation (7), will vary as the distance divided by the base; that is to say, if the base is of constant length, the proportional error will vary as the distance. This is very important consideration in the execution of subtense surveys.

Some manufacturers of subtense equipment recommend the ratio of the distance to the base be limited to 20. The maximum

[2] In Table 1, the values of e_s in the various columns were computed by the equations indicated by the numbers in parentheses in the column headings.

distance for a standard base bar would therefore be 40 meters. It is doubtful that the American surveyor would be content with such short sights, or that, according to Table 1, he would need be in his regular work.

Again it should be noted that estimates of accuracies predicted on probable errors should be accepted with caution. Experience is the best teacher in such matters. However, results obtained from tests under normal field conditions agree very well with those given in Table 1.

The H. Wild Company recommends formulas derived empirically from tests. For distances up to 100m., the formula is $s/4$ mm., s being the distance in meters. The error for distances greater than 100m. is expressed by $(s/20)^2$ mm. This second formula agrees very closely with Table 1. Much greater proportional errors for the shorter distances will be given by the formula applying to lengths of less than 100m.

Kern and Co. give a table of expected errors which are obtained by multiplying the results of equation (6) by $\frac{1}{2}\sqrt{2}$.

CONDUCT OF SUBTENSE PARTY

The conduct of a subtense traverse may vary considerably according to the equipment used and the degree of accuracy desired. Ordinarily a single subtense bar will suffice. The bar may be kept one traverse point either to the front or rear of the instrument. In either case, it serves as the flag at that point. Two bars are convenient when a double distance determination of each course is desired. The extra work involved in reading the angles both to front and rear, and the subsequent computations, will be compensated to some extent by the elimination of possible rerunning. In order to reduce the measured lengths, the subtense bar may be placed on line between the traverse stations.

Additional bars may be added for side shots when topographical control is required, or these side shots may be taken by stadia or other means for which the theodolite is equipped. It may be seen that the equipment for efficient operations on a large scale can run into a considerable investment.

Subtense parties will consist of a party chief, instrumentman, barman, and flagmen and axmen as required. If side shots are taken, or the line is favorable to rapid progress, a recorder will prove economical. The party chief picks the points to be occupied, and in some cases can handle the subtense bar also. In difficult areas, his time will be fully occupied in selecting the stations. On the other hand, the party may be reduced to two men, and conceivably to one alone.

The party moves forward as a unit. The use of interchangeable tripods is of great advantage, but requires leap-frogging the rear tripod to the front. The interchangeable tripods prevent the errors due to eccentricities from accumulating, and only those stations required for subsequent reference need be plumbed or marked. This affords a saving in time, but may cause difficulties in localizing errors and in any rerunning.

SHORT-BASE TRIANGULATION

Short-base triangulation is an extension of the subtense principle. As has been noted, the ordinary subtense equipment is limited as to the distance it can measure. In any extensive survey, there will be times at which it is desirable or necessary to exceed these limits. The solution is the use of base lines longer than possible by the use of the standard bars. The base lines may be measured by regular taping methods, by a subtense operation, or they may utilize special equipment.

The lengths of the longer bases generally preclude orienting them at right angles to the line of sight, and they are placed in conformity with the terrain as nearly approaching the perpendicular as possible. The angle from the base alignment to the line of sight must then be obtained. The angle at the instrument station between the base ends is measured in the same manner as in the subtense method. Therefore, the short-base triangle is simply one in which two angles and one side are known. The apex angle will be quite

small, and ordinarily the base will approach the perpendicular to the line of sight. The criteria of accuracy expressed by equations (5), (6), (7), and (8) may then be applied, with due regard to any greater errors that may exist in the base line.

Short-base triangulation is particularly fitted to picture point control in moderately rough terrain. With base lines of 500 feet, lengths up to two miles can be measured reliably to third order accuracy. Traverse, either by standard tacheometry or tape, is usally compelled to follow roads or railroads. Short-base triangulation, on the other hand, can proceed in any direction where suitable base sites can be found. This may result in a shorter route between connections and a more uniform distribution of picture-control points.

A comprehensive report on some work of the Aero Service Corporation in the field of short-base triangulation was presented at the Annual Meeting of the American Congress of Surveying and Mapping in June 1949 by Mr. Joseph G. Kelley.[3] The system employed utilized taped base lines which were reduced for tape lengths, temperature, suspension, alignment, and grade in the usual manner. Two superimposed bases starting at the same point and on the same alignment, but of different lengths, were used. The two lengths were measured independently, and the distance between their terminals, also. This gave a check on the measurements and reductions. Angles were turned from the common base end to both the outer terminals, so that the distance could be carried independently through two triangles. Other noteworthy features included a code of signals which positively identified the base layout to the angle party without prior communication. It is suggested this paper be read by anyone interested in this type of control.

When suitable conditions exist, the base line can be measured by subtense as shown in figure 7. Starting with the subtense

FIGURE 7.—Use of auxiliary base

bar, l, the length, b, is determined. This length then becomes the base of the triangle lca, and is often referred to as the auxiliary base. If the angles are measured with equal accuracy, the most efficient length of the auxiliary base is equal to $\sqrt{sl}$. Should both expansions be in the ratio of 20 to 1, and the probable error of the subtense angles, $\pm 2''$, the probable error in s will be about 0.1 meter, or 1 part in 8,000. However, this should be taken with a grain of salt, for a slight error in centering targets over the auxiliary base can destroy all reference to the theoretical accuracy.

Naturally, s may be used as a base for a still larger triangle, and so on to the limits of visibility.

A special base-line equipment consisting of suspended tapes or wires, was developed by the Survey of India under the direction of Dr. de Graaf Hunter.

The development consists of a standardized apparatus for elevating, supporting, and applying tension to the tapes, and provision of targets at the tape ends. The tapes are about 80 meters in length and terminate at hooks which fit over a pin at the center of the target. The standardized length is from center to center of pins, hence there is no need for carefully plumbing the target staffs. Any number of tapes can be assembled in series; generally two are used to provide a base of 160 meters. Tension is applied by a weight acting through a bell crank. The weight is visible to the observer at usual distances, and he can verify the correctness of the tension by its position.

The supports consist of a bipod for each point of suspension and guys for the ends. The tapes and guys are customarily wound on the same reel. On arriving at the site, the end of the first guy is staked down,

[3] *See* "Trig-Traverse" by Joseph G. Kelley, SURVEYING AND MAPPING, July–September 1950, Vol. X, No. 3, page 180.

and a bipod erected to support the tape end. The tapes are then unreeled, their junctions being raised on bipods and attached to the targets, and the final guy with attached reel staked down. A small theodolite is used to place the tapes in alignment, and also to measure the angle between the base and traverse line. The anchors are then adjusted to apply the proper tension, and the base is ready for use. As a usual case, the middle target of a two-tape base is placed over the traverse station. The theodolite is used to read vertical angles on the targets for determining the grade, or, in sufficiently even topography, the bipod staffs may be graduated and used as leveling rods.

The dimensions of the tape hooks and pins are included in the tape lengths so that targets are the net distance apart. Provision is made for suspending two tapes in parallel between two targets for comparison. Temperatures are read from thermometers suspended in the air.

All observations for orienting and reducing the base are made by the base party, leaving only the subtense angles and the azimuths to the main observing party. Frequently, the base is placed on line between two traverse stations, in which case the observer need not visit the site. Directions are taken on each of the targets so that the base may be used as a whole or in sections for comparison.

The Hunter short-base system has proved satisfactory in brushy country. The tapes can be suspended above the brush on ridges, or they may span brushy valleys. The performance of the apparatus in a strong wind is problematical. However, there are many regions in which it or some modification may well serve with advantage.

Many of the advantages of the Hunter base apparatus can be obtained by measuring between elevated targets with a suspended tape. The targets of the self centering traverse sets mounted on instrument tripods serve very well for this purpose when the height of brush permits.

METHODS OF CONDUCTING A TRAVERSE WITH SHORT-BASE TRIANGLES

In the prosecution of short-base triangulation, the base sites may be selected at each traverse station, at alternate stations, or between stations.

The first system permits the reading of angles for obtaining the distance in both forward and backward directions. This affords a check on the work as well as an improvement of the accuracy by the repetition. Longer courses involving weaker length determinations may be taken by virtue of this feature. Under given specifications, base lines at all traverse points will give better accuracy at the expense of greater cost.

Base sites at alternate stations reduce the amount of tape measurement, and permit carrying the line over points unsuitable for base sites. Substantially the same checks and improvements in accuracy as in the first method can be obtained by using divided or superimposed bases, and by increasing the number of measurements of the angles. It is believed this use of alternate station sites will prove of greatest advantage and adaptibility in most applications.

In both the above cases, a sharp change in direction of the traverse at a base site may require the use of two base lines to avoid excessive obliquity to the lines of sight. A minimum angle of 60° between the base and traverse lines should be adhered to. Hence, when possible, large changes in direction should take place at the stations between the base lines.

The third method of placing the bases between and approximately on line with the traverse stations permits the stations to be placed at greater distances apart than otherwise desirable or possible from mathematical considerations or ability to bisect the base-end targets. Certain terrain characteristics may render this feature of great advantage. The number of bases per station is the same as for the first method, but the increased distance between traverse stations reduces the number of bases per mile. Also, the problem of orientation with two courses is avoided.

When the base is placed at a distance from the traverse station, there is a problem of orienting the base with the traverse line. A point on the base may be "wobbled in" between the two stations, and the angle turned to the base end. Another possibility is the measuring of the orienting angle at a base-end station, whose direction is subsequently observed from a traverse station in respect to the traverse line. Or, in the case of a base divided into sections, the angle between the base and traverse line may be obtained from the distance angles.

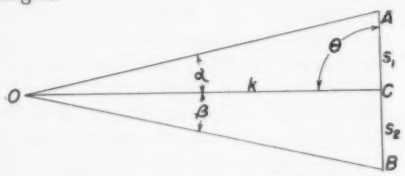

FIGURE 8.—Orientation of divided base

Formulas for this may be derived as follows. Figure 8 represents a two-section base, *ACB*, observed from point *O*, *AC* and *CB* each being known, and lying in the same straight line.

Let *OC*, the distance to the mid-point, equal k, $AC = S_1$ and $CB = S_2$. The angles opposite S_1 and S_2 are denoted by α and β, respectively and the angle of orientation by θ. Then,

$$\frac{k}{S_2} = \frac{\sin(\theta - \beta)}{\sin \beta},$$

or

$$\frac{k}{\sin(\theta - \beta)} = \frac{S_2}{\sin \beta}$$

Similarly,

$$\frac{k}{\sin(\theta + \alpha)} = \frac{S_1}{\sin \alpha}$$

Dividing the second equation by the first,

$$\frac{S_1 \sin \beta}{S_2 \sin \alpha} = \frac{\sin(\theta - \beta)}{\sin(\theta + \alpha)} = \frac{\cos \beta - \cot \theta \sin \beta}{\cos \alpha + \cot \theta \sin \alpha}.$$

Solving for $\cot \theta$,

$$\cot \theta = \frac{S_2 \cot \beta - S_1 \cot \alpha}{S_2 + S_1} \qquad (9)$$

In the case of superimposed bases, let S_1 equal the shorter and S_2, the longer. Then, by derivation as above,

$$\cot \theta = \frac{S_1 \cot \alpha - S_2 \cot \beta}{S_2 - S_1} \qquad (10)$$

In both cases, the angle, θ, is derived from its cotangent and, since it will approach 90° in value, it will vary rapidly with changes in the right hand term. For this reason, it should be computed with 7- or 8-place tables and precise lengths and angles. Even so, considerable error may remain, but, on the other hand, the effect of this error on the computed distance will vary with the sine. Since the sine of angles of such magnitude varies slowly, the error will be small. A check on the base orientation is had by obtaining it from both the backward and forward traverse stations.

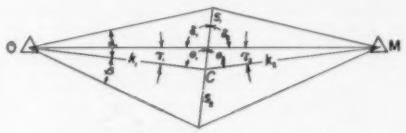

FIGURE 9.—Reduction of remote base

In order to reduce the distances measured to some point on the base to the line connecting the traverse stations, it is necessary to measure the angles between this point and the line, as shown in figure 9. The symbols γ_1 and γ_2 represent these angles as measured at *O* and *M*. The angles between the base and the traverse line *OM* are designated δ_1 and δ_2. They are obviously equal to $(\theta_1 + \gamma_1)$ and $(\theta_2 + \gamma_2)$ respectively, and their sum should equal 180°.

The angles γ_1 and γ_2 should be measured with an accuracy commensurate with the variation of their cosines. Since these angles are small, one pointing direct and one reversed with a 1″ theodolite should be adequate.

It is believed most surveyors will prefer to measure the θ angles in the field in spite of the work involved, and to rely on the above formulas only as a check. Regardless of how θ is obtained, from figure 8,

$$k_1 = S_1 (\sin \theta \cot \alpha + \cos \theta)$$
$$k_2 = S_2 (\sin \theta \cot \beta - \cos \theta) \qquad (11)$$

The length OM (figure 9) then becomes

$$k_1 \cos \gamma_1 + k_2 \cos \gamma_2 \qquad (12)$$

The superimposed base appears to have some advantage from taking one parallactic angle opposite the entire base instead of both angles opposite fractions of it. An advantage would be derived therefore by considering one extremity of the base as the point about which to make the calculations, rather than the mid-point. This extremity should be the one nearest the traverse line.

RESULTS OF TESTS OF THE SUBTENSE AND SHORT-BASE METHODS

The results of a number of tests of the subtense method have been published. Some of them were evidently made under controlled conditions and without respect to economical operations. The following examples were chosen for this paper because they were executed under ordinary conditions by crews not especially familiar with the equipment. Production was desired rather than experimental data.

The first example is the analysis of part of a subtense traverse conducted by Kare Kulvik and reported in Norsk Tidsskrift for Jordskifte og Landmalig, Vol. 22 No. 5–6, 1955. The other is a traverse run by the Army Map Service near Sault Ste. Marie, Mich., for photo-control. This was a short-base project, but the taped bases were checked by subtense, thereby affording a comparison of tape and subtense over short distances.

The Norwegian traverse extended over about seven kilometers and was divided into four sections by five triangulation stations. There were 59 courses from approximately 42 m. to 204 m. in length. The subtense bar was placed near the midpoints of the lines, resulting in 118 measurements with s/b ratios of from 10 to 51.

The subtense angles were observed by six sets with a one-second optical-reading theodolite. A set consisted of a pointing on each target of the bar in both the direct and reversed positions of the telescope, or a total of four pointings and readings. The

TABLE 2

No. of measurements in group	Average length, s	Average mean square error						Proportional error, $\frac{m_s}{s}$	
		of a single set		of average of sets		in computed distance			
		6 sets	4 sets	6 sets	4 sets	6 sets	4 sets	6 sets	4 sets
	m.	"	"	"	"	mm.	mm.		
2	21	2.1	2.3	0.8	1.2	0.9	1.2	1/23900	1/16900
5	29	2.5	1.9	1.0	0.9	2.0	1.9	1/14200	1/15400
6	33	2.3	2.1	0.9	1.0	2.7	2.8	1/12200	1/11750
7	36	2.5	2.1	1.0	1.0	3.2	3.5	1/11500	1/10550
11	42	2.4	2.1	1.0	1.0	4.2	4.5	1/10100	1/9400
10	48	2.8	3.0	1.1	1.5	6.3	8.4	1/7650	1/5800
10	52	2.2	2.0	0.9	1.0	6.1	6.4	1/8550	1/8180
12	58	2.4	2.1	1.0	1.0	7.6	8.4	1/7620	1/6860
11	62	2.4	2.8	1.0	1.4	9.3	12.9	1/6640	1/4800
9	68	2.3	2.2	0.9	1.1	9.9	12.2	1/6810	1/5540
5	72	1.9	1.6	0.8	0.8	9.6	10.2	1/7420	1/7020
11	77	1.9	2.1	0.8	1.0	11.9	15.2	1/6480	1/5090
4	84	1.9	2.1	0.8	1.0	13.0	17.7	1/6420	1/4740
8	87	1.9	1.7	0.8	0.9	12.8	16.1	1/6800	1/5540
3	91	1.7	1.6	0.7	0.8	14.1	16.2	1/6430	1/5630
2	97	1.8	1.5	0.7	0.8	16.4	17.9	1/5930	1/5420
2	102	1.8	1.8	0.7	0.9	18.5	22.4	1/5520	1/4560

circle was advanced 30° between sets to distribute the measurements over the entire limb. Two such sets were observed on the azimuth angles.

A party of only two men was utilized. Work was carried on under any condition of weather which would have permitted other types of survey. The loop closures ranged from 1/7,500 to 1/10,000, indicating a very satisfactory grade of work.

Time studies and records of the effects of weather, fatigue, traffic interference, etc., were made. A further study of the effect of a reduction in the number of sets observed was made by computing all lengths from four sets as well as the six.

In order to condense the results, the measured courses have been grouped according to length in Table 2. The indicated errors are mean-square errors commonly used in Europe instead of the probable error. The mean-square error is approximately 1½ times the probable error of an observation of the same quality.

The angular errors were computed from the residuals of the individual sets, and those for the distance by the application of equation (6). The bulk of the lengths fall between 40 and 80 meters. The indicated error for these lengths varies from 1/10,000 to 1/6,500 which compares well with the loop closures.

Theoretically the errors from the use of four sets should be $\frac{1}{2}\sqrt{6}$ or 1.22 times those derived from six sets. Generally, they are not that large, indicating a diminishing return from the extra observations. The results from six sets are, however, more consistent than those from the four sets. The best results were obtained on cool cloudy days, as is to be expected. Wind had an adverse effect on the accuracy. There was a tendency for the work to improve as time went on, probably due to increasing skill of the observer.

The Sault Ste. Marie traverse consisted of 34 courses connecting 2 triangulation stations. The total length of the traverse was 13.3 kms. The average length of course was 391 m. with extremes of 129 m. and 886 m. The base lines varied from 17 to 58 meters, and the ratio, s/b, between 4 and 19, with an average of 13. These ratios are well within the allowable range.

The apparatus used was a Zeiss II theodolite and traverse targets interchangeable with the theodolite tribrach. Base lines were measured directly between the targets by means of a suspended steel tape which was field compared with a standard at its terminal and mid-points. The subgraduations, which enter into all the base measurements, were not compared. Tension was applied by means of a standard tension handle, and temperature was read from a thermometer attached to the tape. The reduction to the horizontal was obtained from vertical angles taken with the theodolite after it had replaced one of the targets. The targets of this equipment are so designed that they are exactly the height of the theodolite axis.

As with the Norwegian project, the party consisted of men trained as surveyors, but not experienced with the equipment.

Angles were measured by six sets or positions, distributed uniformly over the circle in the same manner as in Norway. The probable error of a single position and of the mean of the positions was computed at all stations from the six observations, and also for the first three.

The base lines were placed at alternate stations. One base end coincided with the traverse station. The angle between the base and line of sight was held to a minimum of 60°. Lengths were computed by the sine formula, using the mean angles obtained by six positions and by three positions.

The following statistics were obtained from the project. (*See* Table 3, p. 486)

It will be noted that the increase in accuracy obtained from taking six positions instead of three does not live up to the theory. The cause for this may lie in the fatigue of the observed, or in movements of the theodolite during the longer term. The same effect is noticeable in the Norwegian report.

The total length of the traverse as com-

TABLE 3

Probable error	Derived from 6 positions	Derived from 3 positions
	"	"
of a single position		
Average	1.2	1.1
Maximum	2.2	2.1
Minimum	0.5	0.2
of the mean value		
Average	0.5	0.6
Maximum	0.9	1.2
Minimum	0.2	0.1

puted from the three-position angle measurements was 0.02 m., or one part in 665,000 longer than from the six positions. The greatest difference on any one course was approximately one part in 9000. The closure between the triangulation stations, using the six-position angles, was 1/8900. This compares with 1/8300 for the three-position measurements.

Comparison of the subtense versus tape measurement of base lines is shown in Table 4. The 17 bases are divided into five groups of similar lengths as was done in Table 2.

TABLE 4

No. lines in group	Average length, s	Average Difference Tape and Subtense	
	m.	mm.	
5	20.7	1.6	1/13,000
7	28.7	3.9	1/7360
2	39.2	6.0	1/6530
1	45.7	13.0	1/3520
2	55.5	15.0	1/3700

These results are below the probabilities indicated by Table 1, especially over the longer distances. In only two cases in the 17 is the length from the tape shorter than by subtense. Since most errors in taping occur on the side of making the distance too great, this consistency may indicate some systematic error in the taped distances. The length of the traverse as computed from the subtense bases is 1.84 meters or 1/7,220 shorter than from the taped bases. The loop closure by subtense bases is 1/5,300.

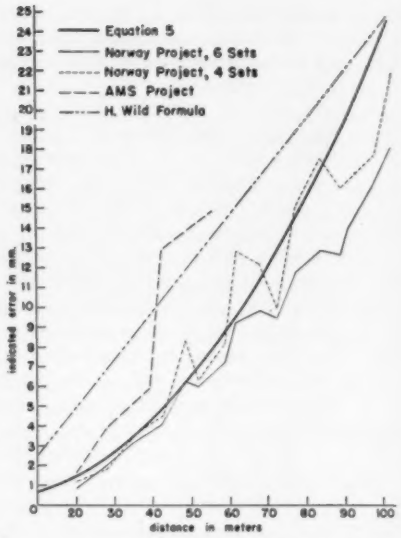

FIGURE 10.—Graphic comparison of formulas and field results

Figure 10 shows by curves the comparison of the results obtained on the Norwegian and the Army Map Service projects, and those indicated by equation (5) and the H. Wild formula. The Norwegian results are obtained from the indicated angular errors; those of the Army Map Service from the differences between taped and subtense distances.

Both the errors from 6- and 4-position angle observations are shown by the curves of the Norway project. There is a noteworthy tendency of the field results to follow the curve of equation (5). Also, the results from six observations are quite consistently better than from four.

The Wild formula, which is linear up to 100 m. appears to indicate errors larger than can be obtained. However, it is crossed by the curve of the Army Map Service work.

There can be no doubt that the subtense method is sound, and that it will obtain satisfactory results. The evidence is, however, that it is a supplement rather than a substitute for the tape. All records indicate the subtense is slower and more costly

than taping in the open, or when lines must be cleared for both methods. The subtense and short-base methods can be valuable under special conditions. When accurate work must be done in busy streets, the subtense may prove indispensable. The cost of the special equipment is a deterrent to the tacheometric method unless there is sufficient work to justify it.

As for accuracy, it is believed the American surveyor will in general be satisfied with the results obtainable, even with a reduced number of angle measurements and fairly long distances. It is hard to beat a tape both for speed and accuracy when it is in the hands of a skilled crew and under conditions suitable to its use. There remains a question, however,—How good is run-of-mine taping? This recalls a remark of an old county surveyor concerning the quality of taping,—"One part in 250 is rotten; one in 500 is good; one in 750 is excellent; and one in 1000—somebody lied!"

Geological Survey to Show Fence Lines on 7½-Minute Maps

According to a policy adopted recently by the Geological Survey, selected fence and field lines will be shown in the future on 7½-minute quadrangle maps in states east of the Mississippi River in which there are no public-land subdivisions. Printed as fine dashed lines in red, the fence lines are expected to serve the same general purpose as section lines on maps in the public-land states. They are intended to assist the map reader to orient himself by providing additional planimetric detail, and to furnish a map framework from which property lines can be developed.

The fence and field lines will be compiled from aerial photographs by plotting those that are clearly visible and that appear to be permanent and useful. The fence-line information will not usually be checked in the field. It will probably be a year or two before maps with the new feature are published.

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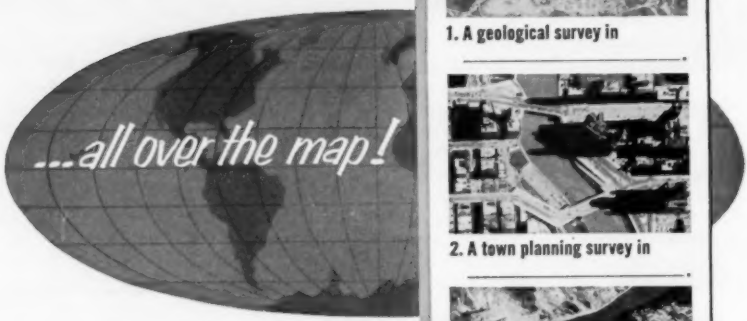

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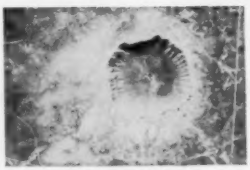
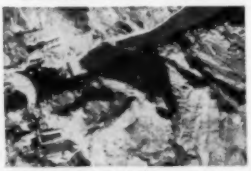
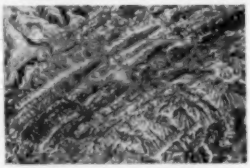


1. A geological survey in _____.

2. A town planning survey in _____.



3. A dam site study in _____.



4. An airborne magnetometer survey in _____.

FAIRCHILD AERIAL SURVEYS, INC.

Los Angeles, Calif.: 224 East Eleventh St. • **New York City, N.Y.:** 30 Rockefeller Plaza • **Chicago, Illinois.:** 111 West Washington St. • **Atlanta, Georgia:** 333 Candler Bldg. • **Long Island City, N.Y.:** 21-21 Forty-First Ave. • **Boston, Mass.:** New England Survey Service, Inc., 51 Cornhill • **Seattle, Wash.:** Carl M. Berry, Box 38, Boeing Field

Repair and Maintenance of Surveying Instruments

By R. L. SARGENT

HOUSTON, TEXAS

IN THESE TIMES, when we are all seeking ways to increase surveying accuracy and, at the same time, reduce costs, it seems especially appropriate, I think, to direct the following to those individuals and organizations who are operating a considerable number of surveying instruments. The owner of a single instrument may also profit, when like the larger operator he considers that unfortunately much of the time and effort spent on the distributing of errors and the devising of numerous short cuts in the sometimes laborious methods of error distribution could be avoided, or at least minimized, if there were a better understanding of the elementary principles and methods of instrument adjustment and maintenance.

I recognize that it may be difficult to interest the advanced geodetic surveyor, an old time property surveyor, and some of our more accomplished mathematicians in such an elementary subject as instrument adjustment and maintenance. This is unfortunate indeed, as much time, effort and money are wasted because of the lack of appreciation for these truly basic requirements for a good surveyor.

I would recommend to all who pursue surveying as a profession that they read and reread, again and again, those early chapters on instrument adjustment found in most every surveying handbook or text. Quite often we find that if we do not make frequent use of the elementary skills, of which instrument adjustment is one, we soon forget them, or at least we become inefficient in their use. It is indeed a deplorable thing, and certainly no credit to our profession, that an embarrassingly large number of surveyors cannot completely and properly adjust their surveying instruments. I say this with considerable accuracy because, over the past decade, I have adjusted several thousand instruments for surveyors, a few of whom were quite prominent. Have not many surveyors become so interested in such subjects as "Which coordinate system or map projection has the greatest merit" or "Politics in the County Commissioner's Court" that they have forgotten how to double center their transits.

While it is important both to be able to recognize when minor instrument adjustment is required and to possess the ability to perform the necessary, it is of equal importance to be able to recognize when a surveying instrument is in need of mechanical attention and complete cleaning. I am sorry if I have to be the one to dispel a popular myth, but I am forced to state that surveying instruments will not last forever. I am sure that you have all heard, or possibly read, that it is almost impossible to wear out a surveying instrument and that they are frequently passed from father to son. While this may occasionally occur, it is certainly not the usual thing, and you may be certain that in such rare cases the owners were real instrumentmen.

One of the first requirements for the proper and convenient maintenance and cleaning of instruments is a well lighted, clean room. The surveyor should strive to do this work with the least possible interruption so that he may be free to concentrate fully on the job at hand.

How often should you clean your instrument? Please note that I say *you* clean your instrument. The answer is obvious—when it gets dirty. Certainly, the instrumentman using his instrument along a busy, gravel

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road will need to clean his instrument much more frequently and thoroughly than one who is surveying grassland or one surveying in some forest area. Conditions around some construction projects are so bad as to require instrument cleaning on almost a daily or, at least, a weekly basis.

The cleaning of the threads on the base plates of levels or transits can be most easily accomplished with a small pan of kerosene and a toothbrush. A very minimum of light grease applied either to the tripod after it is cleaned or to the base plate of the instrument will do much to prevent the base plate from being jammed on the head. By screwing in, as far as possible, two leveling screws, it is often quite easy to remove the remaining two. When this is done, threads of the leveling screws as well as the bushings, or the threaded holes in the leveling spider, can be more readily, and certainly more thoroughly, cleaned than by superficial wiping off the dust and dirt which can sometimes be seen on the lowest part of the leveling screws. If one of the commercial cleaning solvents is not available, ordinary kerosene and bristle brushes, similar to those used to clean revolvers, will remove accumulated grease, grit, and dirt from the screw threads.

The same procedure can be applied to all the clamp and tangent screws, as well as the tangent spring barrels and housings. In removing the upper tangent screw bracket, be especially careful that none of the screws from a different spot on the instrument is improperly used to refasten the bracket in place. Usually the length of these screws is quite critical and one that is too long will bind the circle.

Telescope axle bearings can be quite readily cleaned by removing the bearing caps above the telescope axle and carefully lifting out the telescope assembly. A word of caution at this point—be very careful in laying the telescope assembly on the work bench to prevent damaging the vertical circle graduations. The axle bearings may be cleaned with a soft cloth or lint-free lens tissue and relubricated before replacing.

Should there be any binding in the objective focusing mechanism on an instrument with either internal or external focusing telescope, the cause may be eliminated by removing the objective lens, as well as the focusing pinion and telescope slide, after which both the rack and pinion may be thoroughly cleaned and relubricated. Lint-free lens tissue, or lint-free cloth, slightly moistened in a cleaning solvent, may be used to clean the inside of the telescope barrel. On internal focusing telescopes, while the telescope slide is out of the telescope barrel, it is an ideal time to clean the focusing lens, after which the rack and pinion as well as the slide can be lubricated and reinserted in the telescope barrel. Some instrumentmen prefer to leave a very light film of grease near both the objective and eyepiece ends of the telescope, as this serves as a dust catcher and is found to be very helpful in preventing much of the dirt and debris falling on the focusing lens or crosshairs, whether the latter be of spider silk or the etched-on-glass variety. Before cleaning and installing the objective lens, check to be sure that the two lens elements are secure in the mount. Some are held in place by a threaded retaining ring while others are "bezzeled in." The latter are especially bad offenders at becoming loose and, at this point, it might be well to note that many errors in collimation are simply the result of either the lens elements being loose in the mount or the mount being loose in the telescope barrel. No adjustments involving the crosshairs should ever be attempted without first determining if the objective lens is secure.

No other part of the optical system deserves as much careful cleaning as does the eyepiece system. Small amounts of dirt and grease appearing on these lenses cause much greater loss of telescope efficiency than does an equal amount of dust or dirt on the objective lens. Most eyepiece systems are held in place either by screws placed at right angles to the telescope or by threaded rings or collars near the eyepiece end of the telescope. Removing the entire eyepiece system will usually permit the eyepiece tube, with its four lenses, to be removed. It is then possible to remove the two individual cells, which are usually close friction fits. For

the relatively inexperienced, I suggest that the cells and their lenses be cleaned one at a time and replaced. This will prevent interchanging the lenses. It goes without saying, or it should go without saying, that one should be very careful when working around the eyepiece end of the telescope not to break or damage the crosshairs. On American-made, conventional instruments, the crosshair rings are immediately forward of the eyepiece system.

With reasonable care, a few basic cleaning materials, and proper screwdrivers, most any surveyor worthy of the name can perform the simple operation described. At this point, however, additional care is recommended in the maintenance of transits. Remove the cap on which the plumb bob chain is attached, thereby exposing the center nut. Most makers provide a key which should, of course, be used when removing this nut. The instrument should be placed on its side while removing the center nut. Then with both hands on the instrument, one on the standards and one on the base plate, very carefully place the instrument in an upright position on the bench or table. In the case of a transit, it may be necessary at this time to remove the horizontal tangent screw bracket, after which it is possible to grasp the standards, one in each hand and lift straight up, gently, thereby exposing the spindle and horizontal circle for cleaning. One should be especially careful of avoid rubbing the horizontal circle or vernier with anything of an abrasive nature. In fact, the less rubbing of any kind the better. Possibly the best advice to give at this point would be to limit the cleaning of the horizontal circle and verniers to that which can be accomplished with a soft camel hair brush. Damage to the horizontal circle and verniers require some of the most expensive repairs. If the lower motion clamp is loosened, the horizontal circle may be lifted from its socket and both the inner and outer surfaces cleaned and lubricated.

The make, or type, of lubricant to be used at various places on surveying instruments deserves some mention and probably the most accurate thing that can be said is, "Use very little." Most of the instrument manufacturers will supply instrument oil and instrument grease of the proper type and viscosity but, unfortunately, they cannot supply the judgment that must be used in their application. Suitable lubricant and grease can also be obtained in some of the better know instrument repair shops throughout the country whose owners are co-operative. It is always well to follow the manufacturer's recommendations in the selection and application of lubricants.

No discussion concerning the cleaning and general maintenance of surveying instruments would be complete without some mention of the European-type theodolites or transits. They are rapidly coming into more widespread use. These instruments, which are capable of great accuracy, are made up of a great number of parts, some of which are fitted and machined to remarkably close tolerances. The disassembly, cleaning, and complete adjustment of these instruments should be left to the experienced repairman, a relatively few of whom have had sufficient experience to undertake complete major overhauls of the European theodolites. The adjustment of optical micrometers, the centering and cleaning of graduated glass circles, and the realignment of lenses and prisms on most of the foreign theodolites, are time consuming jobs requiring a cleanliness too seldom found in the repair shop in the United States. This extreme cleanliness is required because of the high magnification of the reading microscopes involved. It is unfortunate, but true, that these microscopes magnify tiny particles of dust and dirt as well as circle graduations.

The cleaning and maintenance, as well as the adjustment, of most of the European levels are not so different from what is required for the American product and can, with a little forethought and care, be performed by most instrumentmen without difficulty.

In closing, I would like to call your attention to an often neglected piece of surveying equipment, the tripod. Seriously worn tripod-leg bolts and the matching holes in the tripod head are frequent sources of error and have undoubtedly resulted in many needless attempts at adjustment on the instrument

proper. This same may be said of loose tripod shoes. All too frequently the tripod does not receive the same care that the instrument itself receives, though a tripod in poor condition can contribute greatly to poor instrument work. Few surveyors return their tripods to repair shops for service. It seems they always suspect the difficulties are in the instrument alone. Sometimes they are, but quite often it is the tripod that is the culprit. The apparent accuracy of an instrument can be prolonged considerably if frequent attention is given to its tripod.

To individuals or organizations who contemplate frequent instrument adjustment, I suggest the establishment of either a testing yard or a collimator room, either of which greatly increases the speed and convenience with which the adjustments can be performed. Again, several manufacturers, as well as some of the better known repair shops (unless some of the latter are afraid of losing business) will generally provide the necessary equipment and instructions for installing a collimator set-up where instruments can be adjusted with great precision, convenience, and accuracy.

Repairs and adjustments requiring specialized equipment and specialized skills, other than those I have mentioned above, should be entrusted only to a complete repair shop, properly equipped and staffed, or returned to the manufacturer.

Have we not all seen fine instruments placed on the bed of a pickup truck and bounced merrily along to the job site and then made to endure eloquent profanity for not holding their adjustment, or, worse still, some innocent manufacturer or repair shop unjustly blamed for poor manufacture or workmanship.

Seeking the advice and suggestions of instrument manufacturers, reference to one or more of the manuals published by various instrument makers, reference to almost any standard surveying text, plus the application of reasonable judgment and a sincere desire to operate only an instrument that is capable of good work, will, I believe, do much to improve the quality of all our surveying. Certainly it will minimize some of the errors. This, in turn, will not only make our work more pleasant but more lucrative as well.

Buggy Traverse—Old and New

Tijdschrift voor Kadaster en Landmeetkunde, Vol. 72, No. 4, August 1, 1956, came across the desk of our Executive Secretary. His sharp eye noted a reproduction of an illustration from "The Story of Maps" by Lloyd A. Brown.

This illustration shows two 16th century gentlemen riding in a four-wheeled carriage drawn by a team of horses. On one of the horses is mounted a footman, wearing a tall hat and carrying a whip. Apparently he is the one who is responsible for guiding the carriage along its appointed route. The two gentlemen riding the back of the carriage are apparently conducting the survey, using wheel revolutions as a measure of distance and a compass for determining directions. Obviously this is meant to show route-sketching operations as conducted in the 16th century.

Mr. Dix referred the publication to us with the following note clipped to the appropriate page.

"In the early days of TVA, TVA mappers made 'hasty reconnaissance' county maps by rapid automobile surveys, wherein the speedometer gave distances, and sun compass mounted on the hood gave direction. Not too far apart from the 16th century job deluxe."

All right—so 16th century methods, slightly modified, were used in the 20th century. What of it? The main thing is to get the end result, with all needful accuracy, at the least possible cost. Just because a method is old is no sign that it is no good. We remember back to the days when "buggy traverse" was s.o.p. in the Geological Survey and, for the purpose for which it was intended and for the use that was made of it, served very well. No one method of operation, no one type of surveying equipment, no one manual of instructions can fill the bill for all types of surveys. The man who gets the most for his money in survey work is the one who will adapt his equipment and methods to the job in hand at the time.

—Editor

Surveying and Mapping News

Members are requested to send in surveying and mapping news items for publication in SURVEYING AND MAPPING.—EDITOR.

CURRENT SURVEYING AND MAPPING LITERATURE

MAGAZINE ARTICLES

General Interest

SPECIALIZATION PAYS OFF FOR RAND McNALLY & COMPANY. H. H. Slawson. *Modern Lithography,* Vol. 24, No. 7, July 1956. (General article on the work and products of the well-known mapmaking firm, commemorating the 100th anniversary of its establishment, and illustrated by photographs of its personnel and the interior of its plant.)

FUNCTIONAL ENGINEERING PRACTICES IN THE DRAFTING ROOM. Thomas R. Sainsbury. *Bureau of Ships Journal,* Vol. 5, No. 3, July 1956. (Recounts efforts to overcome the lack of training in drafting skills.)

MIND YOUR LANGUAGE. Charles M. Bayer. *Civil Engineering,* Vol. 26, No. 8, August 1956. (A newspaper man expresses the wish that engineers and other professional men could express themselves clearly and effectively to laymen.)

TRAINING GROUND FOR SURVEYORS AND MAPPERS. Clair E. Ewing, Colonel, USAF. *Bulletin Geodesique* (The Journal of the International Association of Geodesy.) Nouvelle Serie, No. 40, 1 June 1956. (An advanced student's evaluation of the curriculum of the Institute of Geodesy, Photogrammetry and Cartography of The Ohio State University founded by Past President George H. Harding of ACSM.)

GEODETIC SURVEYS IN ALASKA. Charles A. Whitten. *The Military Engineer,* Vol. 48, No. 324, July–August 1956. (Non-technical account of past and present survey operations in Alaska.)

SCIENTISTS AND ENGINEERS: QUANTITY PLUS QUALITY. Lee A. DuBridge. *Science,* Vol. 124, 3216, August 17, 1956. (Views on the causes of the shortage of engineers and scientists and possible cures for it.)

PLANT SECURITY. Major Abraham Glass. *The International Blue Printer,* Vol. 29, No. 8, September 1956. (Address on the Industrial Security Program given at the 30th annual IABPAI convention in Los Angeles.)

WHAT THE FUTURE HOLDS FOR THE EARTH SATELLITE. R. P. Haviland. *General Electric Review,* Vol. 59, No. 5, September 1956. (Illustrated nontechnical explanation of the theory behind the earth satellite, its instruments and the possibility of its contribution to mapping and geodesy.)

Cartography

THE CASTLEMAINE MAP. No author given; appears under section on "Contemporary Cartography." *Cartography,* Vol. 1, No. 3, March 1956. (Describes methods used to produce the first standard 2-inches-to-1-mile map by the Victorian Crown Lands and Survey and uses a portion of the map as an illustration.)

HAND LETTERING AND "STICK-ON" LETTERPRESS. J. J. Ovington. *Cartography,* Vol. 1, No. 3, March 1956. (Argues the case for handlettering.)

THE COMPUTATION OF GEODETIC AREAS OF STANDARD MAP SHEETS IN VICTORIA. E. T. Homewood, Department of Lands and Survey, Victoria, Australia. *Empire Survey Review,* Vol. 13, No. 101, July 1956. (Describes procedure adopted and gives formulas applied.)

MAPPING THE FALKLAND ISLANDS DEPENDENCIES. Petra Leay. *The Polar Record,* Vol. 8, No. 53, May 1956. (An account of surveying and mapping activity in a little-known part of the world.)

THE OBLIQUE MERCATOR PROJECTION. L. P. Lee. *Empire Survey Review,* Vol. 13, No. 101, July 1956. (A discussion of the properties of this projection with formulas for its construction and a geometrical demonstration of its proof.)

SIGNPOSTING THE SEA. Noel Richley. *Nautical Magazine,* Vol. 176, No. 1, July 1956.

(Brief account of the charting activities of the British Admiralty.)

GRAPH-STRIP. Karl W. Fretcher, Research Technologist under direction of Charles W. Bennett, Chief, Map Reproduction Branch. *Modern Lithography*, Vol. 24, No. 8, August 1956. (Detailed, illustrated description of a strip process developed and used in the Geological Survey.)

PLATE MAKING AND HUMIDITY. Jerry M. Greeson. *The National Lithographer*, Vol. 63, No. 8, August 1956. (Discussion of a well-known problem in lithographic technique.)

A METHOD FOR DRAWING THE GREAT CIRCLE PATH BETWEEN ANY TWO POINTS ON EARTH. J. H. Meek. *Geophysical Research*, Vol. 61, No. 3, September 1956. (Quick and convenient ways are given of tracing around the earth the great circle joining two points or the great circle of given bearing at a point.)

Control Surveys

THE FUTURE OF RADIAL TRIANGULATION. R. Roelofs. *Photogrammetria*, Vol. 12, No. 4, 1955–1956. (Suggests that development of new instruments may revive use of the method and illustrates his theory by numerous diagrams and formulas.)

AN ANALYTICAL METHOD OF AERIAL TRIANGULATION. Dr. Ugo Bartorelli. *Photogrammetria*, Vol. 12, No. 4, 1955–1956. (Mathematical discussion of method.)

ANALYTICAL AERIAL TRIANGULATION AND COMPARISON BETWEEN IT AND INSTRUMENTAL AERIAL TRIANGULATION. G. H. Schut. *Photogrammetria*, Vol. 12, No. 4, 1955–1956. (An argument for the feasibility of the analytical method in light of the development of new instruments.)

RATIONAL ADJUSTMENT OF BLOCKS OF AERIAL TRIANGULATION. A. J. van der Weele. *Photogrammetria*, Vol. 12, No. 4, 1955–1956. (Suggests a method which, in some cases, may save time and money without impairing quality.)

AIRBORNE CONTROL METHOD OF AERIAL TRIANGULATION. T. J. Blachut. *Photogrammetria*, Vol. 12, No. 4, 1955–1956. (Describes two new techniques to allow bridging of longer arcs.)

A CONTRIBUTION TO THE PROBLEM OF ANALYTICAL AERIAL TRIANGULATION. H. G. Jerie. *Photogrammetric Engineering*, Vol. 22, No. 1, March 1956. (Presents a method designed for computing directly the elements of absolute orientation by using "dependent pairs" instead of "independent stereo-pairs" which require subsequent work for their mutual correlation.)

FIELD USE OF THE GEODIMETER. C. K. Waller. *Cartography*, Vol. 1, No. 3, March 1956. (Description of the operation of the geodimeter as a practical field instrument in Australian surveying.)

INTRODUCTION TO THE GEODIMETER. G. R. L. Rimington. *Cartography*, Vol. 1, No. 3, March 1956. (Description of the device which is regarded as well adapted to the problems of Australian mapping.)

APPLICATION OF TWO-RANGE DECCA TO HYDROGRAPHIC OPERATIONS IN CANADA. Ian A. Miller. *The Canadian Surveyor*, Vol. 13, No. 2, April 1956. (Describes a refinement of the Decca navigational aid as applied to hyprographic surveying.)

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THE STATISTICAL CONTROL OF AERIAL TRIANGULATION. D. W. G. Arthur. *The Photogrammetric Record* (London), Vol. 2, No. 7, April 1956. (Expresses belief that some form of statistical control is necessary in numerical aerial triangulation.)

AERIAL ELECTRONIC SURVEYING. Colonel B. B. Hunkapiller, USAF. *Navigation*, Vol. 5, No. 2, June 1956. (Discussion of geodetic surveying by use of aircraft with special reference to shoran and hiran methods.)

CRUSTAL MOVEMENT IN CALIFORNIA AND NEVADA. C. A. Whitten. *Transactions American Geophysical Union*, Vol. 37, No. 4, August 1956. (Describes the geodetic approach to an evaluation of earth shifts due to seismic forces.)

Education

THE NEW GRADS—WHERE DID THEY GO? ENR Staff Report. *Engineering News-Record*, Vol. 156, No. 25, June 21, 1956. (Analysis of employment of new engineer graduates from various representative engineering schools.)

Instruments

INTRODUCTION TO THE GEODIMETER. G. R. L. Rimington. *Cartography*, Vol. 1, No. 3, March 1956. ("A 'down to earth' description of an instrument of great potential use to Australian Mapping.")

FUTURE OF THE TELESCOPIC

PRINTER-RECTIFIER. Dr. Gino Parenti. *Photogrammetria,* Vol. 12, No. 4, 1955–1956. (Progressive development and improvement of the photo-printer.)

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THE COINCIDENCE READING GEODETIC TAVISTOCK THEODOLITE. E. Wilfred Taylor. *Empire Survey Review,* Vol. 13, No. 101, July 1956. (Detailed, illustrated description designed to eliminate weaknesses in previous models.)

Property Surveys

MORE THAN BOUNDARY LINES. William D. Pattison. *Our Public Lands,* Vol. 6, No. 1, February–March 1956. (Notes on the early achievements of surveyors for the General Land Office.)

TRAIL OF THE TRANSIT. Robert S. Halliday. *Our Public Lands,* Vol. 6, No. 1, February–March 1956. (Biographical sketch of the highlights in the career of Andrew Nelson, the oldest veteran among the land surveyors of the Bureau of Land Management.)

PUBLIC LANDS AND CADASTRAL SURVEYS IN QUEBEC. Dr. Georges Cote, F. R. I. C. S. *The Canadian Surveyor,* Vol. 13, No. 2, April 1956. (Detailed historical discussion.)

MEASUREMENT OF STAND DENSITY IN FOREST PHOTOGRAMMETRY. S. T. B. Losee. *The Canadian Surveyor,* Vol. 13, No. 2, April 1956. (Explanation of the basic application of the photogrammetric method to forest surveys.)

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Topography

SMALL SCALE MAPPING. T. J. Blachut. *Photogrammetria,* Vol. 12, No. 4, 1955–1956. (Description of general development, achievements, and trends in the field and summary of the more important information obtained through a questionnaire distributed to all the member countries of the International Society of Photogrammetry.)

QUANTITATIVE EVALUATION OF PHOTO INTERPRETATION MAPPING. Harold E. Young and Ernest G. Stoeckler. *Photogrammetric Engineering,* Vol. 22, No. 1, March 1956. (Discussion of the accuracy of photo interpretation used in the preparation of the various elements included in mapping.)

AIRPHOTO INTERPRETATION OF A PROVINCE. H. L. Cameron. *The Canadian Surveyor,* Vol. 13, No. 2, April 1956. (Discussion of the various applications of photogrammetry to research projects in Nova Scotia.)

COMPASS SURVEYING GROWS UP—THE COMPASS-THEODOLITE METHOD OF ECONOMICAL SURVEYS. Thomas E. Riley. *The Canadian Surveyor,* Vol. 13, No. 2, April 1956. (Primarily a description of a method employing a recently developed instrument, the compass-theodolite, in forestry surveys.)

A METHOD OF SUPPLYING CONTOURS FROM FOUR SUITABLY PLACED SPOT HEIGHTS USING PARALLAX BAR OBSERVATIONS ON A PAIR OF PHOTOGRAPHS. H. G. Reading. *The Photogrammetric Record* (London), Vol. 2, No. 7, April 1956. (Description of method.)

THE USE OF PLOTTING MACHINES FOR 1:1,250 AIR SURVEY BY THE ORDNANCE SURVEY. Major D. V. Hutchinson. *The Photogrammetric Record* (London), Vol. 2, No. 7, April 1956. (Brief historical summary of the employment of plotting equipment by the Ordnance Survey.)

A NEW PHOTO METHOD FOR MEASURING THREE DIMENSIONAL OBJECTS. Mylon Merriam. *Photographic Engineering,* Vol. 7, No. 2, 1956. (Describes a new photographic method, developed by the Army Map Service, for measuring the spatial dimensions of three dimensional objects.)

DESIGN FOR A TOPO BEACON. Lt. Col. C. A. Biddle. *Empire Survey Review,* Vol. 13, No. 101, July 1956. (Describes construction of an inexpensive portable target for field surveying.)

BOOKS AND PAMPHLETS

THE HISTORY OF THE TELESCOPE. H. C. King. Charles Griffin and Company Limited, London, 1955. xvi and 456 pp. 50s. net.

OFFICE AUTOMATION, INTEGRATED AND ELECTRONIC DATA PROCESSING. R. Hunt Brown, Automation Consultants, Inc., 1955. 283 pp.

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LETTERING AND ALPHABETS. J. Albert Cavanagh. Dover Publications, Inc., Dept. DA, 920 Broadway, New York 10. $3.00 cloth, $1.00 paper.

MAPS AND WATER. Hugh C. Mitchell, Principal Mathematician (Retired) U. S. Coast and Geodetic Survey. Published by the author. Washington, D. C., March 1956.

TERRAIN MODELS AND RELIEF MAP MAKING. U. S. Department of the Army. GPO, 1956, 69 pp. (TM 5–249.)

MAKING AND USING A TELESCOPE. H. P. Wilkins and P. Moore. Eyre and Spottiswoode Limited, London, 1956. 160 pp. 12s. 6d. net.

SUBDIVISION IN DELAWARE COUNTY 1951–1955. Delaware County, Pennsylvania, County Planning Commission. Media, March 1956, tables, maps, 7 pp. Map information bulletin No. 10.

THEODOLITE DESIGN AND CONSTRUCTION. 2nd edition. E. W. Taylor. York (Eng.): Cook Troughton and Simms, Ltd. 1956. 136 pp.

SURVEY OF KENYA, ADMINISTRATION REPORT, 1955. Government Printer, Nairobi, 1956. 25 pp., tables, progress diagrams.

CARTOGRAPHIC AERIAL PHOTOGRAPHY. U. S. Department of the Army. Washington, 1956, 72 pp. TM 5-243.

MAPS. Walter W. Ristow. Quarterly Journal of Current Acquisitions, Vol. 13, No. 4, August 1956. (Annual report of the Map Division, Library of Congress.)

DISTINCTIVE RECENT MAPS

The increasing tempo of activities in Antarctica, related to the program of the International Geophysical Year, 1957–58, has stimulated preparation of new maps of the south polar lands. Under the sponsorship of the U. S. National Committee for the I.G.Y., the American Geographical Society has prepared a complete revision of its may of *Antarctica* first issued in 1928. The new map is drawn on a polar stereographic projection at the approximate scale of 1: 3,000,000. It is printed on four sheets, each measuring 42 by 42 inches. Land elevations are indicated by generalized contours spaced at 200, 500, 1000, and 1500 meters, and at 500 meter intervals thereafter. Submarine contours are at 200, 500, 1000, and 2000 meters, and at 1000 meter intervals below this level. The relation of the United States to Antarctica, and the status of mapping in Antarctica as of December 1955, are shown on inset maps.

The Antarctic map has not been printed because it will be brought up-to-date during the next two years as new data are received. Black and white contact prints ($7.00 for the set of 4 sheets) may be ordered from the Society. A reduced edition (1:6,000,000) on a single sheet, printed in black and two shades of blue, is available at one dollar (folded) and two dollars (rolled) per copy.

The National Mapping Office of Australia, Canberra, has also issued a new (1956) edition of its map of *Antarctica* first published in 1939. It is at the scale of 1: 10,000,000 and measures 37 by 28½ inches. "Coastal Regions of the Australian Antarctic Territory" are shown in an enlarged inset (1: 7,000,000), and a reduced inset map (1: 60,000,000) portrays "The Antarctic Continent in Relation to the Principal Land Masses of the Southern Hemisphere."

Map of the Antarctic Regions is a publication of the New Zealand Lands and Survey Department, Wellington, New Zealand. The scale at latitude 60° S. is 1: 16,000,000, and the map sheet measures 30 by 29 inches. Land areas are shown in buff and waters and ice shelves in blue. Areas claimed by members of the British Commonwealth are outlined in red. Published in 1955, this is the second edition of the map.

The U. S. Geological Survey published in 1955 a map showing *Oil and Gas Fields of the United States.* It was compiled by Ann C. Coe, Louis C. Conant, and Sophia Drakoulis and is based on data mostly as of August 1, 1955. Oil fields, gas fields, oil shale regions, areas of basement rock, distinctive structural basins, oil and gas pipelines, and refining centers are indicated by appropriate colors or symbols. The map, which is at the scale of 1 : 2,500,000, is printed on two sheets each measuring 48½ by 39 inches. Copies may be ordered from the Geological Survey, Washington, D. C. at $2.00 apiece.

A Map of the United States is the supplement for the September 1956 *National Geographic Magazine.* The last previous National Geographic map of our country was published in 1951. The new map is at the scale of 72 miles to an inch—larger than the 1951 edition.

There have been a number of changes in the United States during the past five years and many of these are recorded on the map. It includes, for example, 2200 miles of high-speed non-stop expressways which have been built since 1951. Also shown are such recent engineering projects as the Lake Pontchartrain and Straits of Mackinac bridges, the dams along the Missouri River, and the St. Lawrence Waterway. One hundred National Parks and Monuments are also located. There are inset maps of Alaska, Hawaii, New York City and vicinity, and New Brunswick and Nova Scotia.

A *Preliminary Geological Map of Connecticut* was published in 1956 by the Connecticut Geological and National History Survey. Compilers are John Rodgers, Robert M. Gates, Eugene N. Cameron, and Reuben J. Ross, Jr. Triassic rocks of the Newark group, primarily in the central part of the State, and pre-Triassic rocks of western and eastern Connecticut, are shown by letter symbols. Faults and geologic contact lines are also marked. The map scale is 1: 253,440 and measurements are 20 by 27 inches. The base map was prepared by General Drafting Co., Convent Station, New Jersey.

James A. Bier has prepared an *Ohio Landform Map*, which was published in 1956 by the Ohio Division of Geological Survey, Columbus. Using the perspective technique perfected by A. K. Lobeck and Erwin Raisz, the map portrays the general physiographic character and regions of the State. The scale is 1: 1,250,000 and the size 14 by 13 inches. Bier's map is very similar to the "Physiographic Map of Ohio," prepared by Reuel B. Frost, and published in 1931 by the Geographical Press.

The State of Illinois each year derives almost two and a half billion dollars from the output of its mines, quarries, and pits. The distribution of these rich natural resources is shown on a map of *Mineral Industries of Illinois* compiled and prepared by the Educational Extension Division, State Geological Survey, Urbana, Illinois. Resources are grouped under the headings of Mineral Fuels, Rock and Rock Products, Sand and Gravel, Clay and Clay Products, Groundwater, and Fluorspar and Metals. The map, which was published in 1955, is at the scale of 1: 500,000 and measures 48 by 28 inches.

Sten Sture Paterson, Department of Geography, Royal University of Göteborg, Sweden, has compiled an interesting map of the *Forest Area of the World*. Printed in 1956 by Kartografiska Institutet of Stockholm, the map shows, by a system of open and colored squares, "accessible forest," "inaccessible forest," and "other forest." Extent of forest areas is indicated by size and number of squares. International boundaries, railroads, and major inhabited cities and towns are also shown. The map is laid out on Goode's interrupted homolosine projection. It is 30 by 52 inches and is at the scale of 1: 30,000,000.

Befolkningens fördelning i Sverige is a new population distribution map based on the 1950 census of Sweden. It was compiled by Tidningsstatistik Aktebolag, and published by Generalstabens Litografiska Anstalts Förlag, Stockholm 16. Population is shown by dots in the open country and graduated circles classify cities by population groups. There are six enlarged insets of major concentrations of population. The scale of the map is 1: 300,000 and it measures 47 by 21 inches.

Regions Agricoles de France is a colorful nine-sheet map outlining the agricultural regions of that country. It was compiled under the sponsorship of Institut National de la Statistique et des Etudes Economique and the Bureau de la Statistique du Ministère de l'Agriculture utilizing the regions delimited by the Directions des Service Agricoles. The map, which is at the scale of 1: 500,000, unfortunately does not have a legend. A separate brochure naming and describing the regions may be ordered from Institut National de la Statistique et des Etudes Economique, 29, Quai Branly, Paris, France. The price is 150 francs.

A 1955 economic map of France (*Chambre de Commerce et Regions Economiques*) has been compiled and published by L'Assemblée des Presidents des Chambres de Commerce de L'Union Française, and printed by the Société Française de Cartographie. Economic regions and Chamber of Commerce administrative areas are outlined, and various industrial, commercial, and educational centers are located. The map is at the scale of 1: 1,750,000 and measures 24 by 25 inches. There are small inset maps of Algeria and Corsica.

Dr. Joseph Klatzmann, of the French Institut National de la Statistique et des Etudes Fconomiques is the compiler of a new *Carte de L'Utilisation des Terres en France*. It shows the principal types of agricultural land use, with coefficients of intensity, by colored bars of varying width. A descriptive "Notice" describing the system and symbols used on the map is printed within the left margin. The map measures 27½ by 31 inches and is at the scale of 1: 1,400,000.

The Central Office of Geodesy and Cartography, U.S.S.R. Ministry of Internal Affairs, Moscow, published in 1955, a detailed and colorful Forest Map of the U.S.S.R. (*Karta Lesov S.S.S.R.*) in 32 sheets. The map, which is at the scale of 1: 2,500,000, is accompanied by a composite map, at the scale of 1: 15,000,000, on which the index grid is superimposed. Compilers of the map are F. M. Kozlova and V. P. Sepliceva. Appropriate colors differentiate fifteen predominant forest types.

A *Railway Map of India*, corrected to March 31, 1955, is a new accession in the communications group. It was published under the direction of the Surveyor General of India and printed at the Survey of India Offices, Dehra Dun. Colors differentiate single and double tracks, types of gauge, and routes sanctioned or in construction. The scale of the map is 1: 4,250,000 and it measures 30 by 39 inches.

The Surveyor General of Ceylon published in February 1956 a *Land Utilization Map of Ceylon* at the scale of 1: 1,500,000. "Paddy," "Coconut," "Tea," "Rubber," "Other Cultivation,"

and "Forest Reserves," areas are indicated in different colors. Symbols locate nurseries, orchards, feed and seed stations, agricultural research stations, etc. Roads, railways, and administrative boundaries are also shown. Measurements of the map are 12 by 8 inches.

The wine industry of Algeria is presented cartographically on *L'Algérie Vinicole* prepared under the sponsorship of the Ministère de l'Agriculture, Gouvernment Général de l'Algérie and professional wine growers associations of Algeria. The map is associated with the "Atlas de la France Vinicole," prepared under the editorship of L. Armat, 80, Boulevard Haussmann, Paris, 8, France. The principal map is at the scale of 1: 1,000,000. There the enlarged insets (1: 500,000) of the major vineyard centers bordering Alger and Oran.

The first two sheets (of 15) have been received of Marcel Soret's *Carte Ethnique de l'Afrique Equatoriale Française*, at the scale of 1: 1,000,000. The series is being compiled under the sponsorship of Intitut d'Etudes Centrafricaines, Office de la Recherche Scientifique et Technique Outre Mer (France). The two sheets in hand were printed in 1955 by Service Geographique de l'Afrique Equatoriale Française, Cameroun. Sheet No. 1 covers the Brazzaville area, and No. 2 entitled "Point Noire," is immediately to the west. Colored symbols differentiate more than 50 ethnographic groups on the two maps.

The *Pastoral Map of the Northern Territory of Australia* delimits pastoral and mission-lease areas, pastoral holdings, and aboriginal and other reserves, and shows stock routes, highways, railway and telegraph lines, as well as tidal flats, swamps, mangroves, and spot elevations. It was compiled in the Survey Office of the Northern Territory Administration and published in 1955 by the National Mapping Office, Canberra. The scale is 1: 2,000,000 and the measurements are 36 by 24 inches.

A *Geological Map of the British Territories in Borneo* was published in 1955 by the Geological Survey Department, Kuching, Sarawak. The map, at the scale of 1: 1,000,000, was prepared in co-operation with Sarawak Oil Fields, Ltd., and the British Malayan Petroleum Company, Ltd. Twelve formations ranging in age from "Ultra-basic" to Quaternary are delimited. The map also shows international boundaries, height of mountains in feet, roads, and railroads. It measures 29 by 43 inches and is issued folded with a protecting cover.

—WALTER W. RISTOW
Library of Congress

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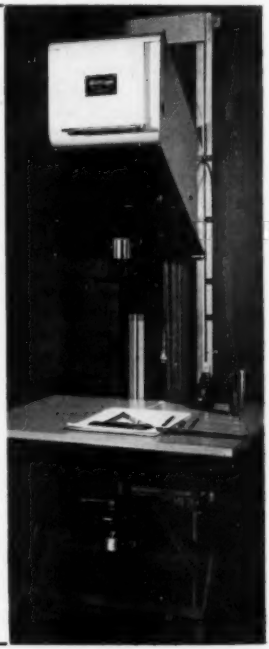

Books in Review

GEOLOGY AND OURSELVES. F. H. Edmunds. *Philosophical Library, Inc.,* New York, 1956. 256 pages + 10 plates. $10.00.

Although written by a geologist, this book is written for the layman. As stated by the author, the book is aimed at answering the question, "What is the economic use of geology?" It serves this purpose admirably. Although it will not be light reading for those with no knowledge of geology, the material presented is clearly and concisely stated, adequately illustrated, and should be both understandable and instructive to the serious reader.

More than one third of the book deals with the history of geology, the fundamentals of geology, and the common techniques of geology. Of particular interest is Chapter V, Geological Surveys and Maps; the author shows clearly the differences in approach and in methods between making topographic maps and making geologic maps.

The remainder of the book is concerned with the ways in which geology affects or contributes to a wide variety of economic endeavor. The chapter on water supply is particularly well done; the occurrence and hydrology of underground water are related to the geologic environment. Geologic factors affecting water storage above ground are discussed. The chapter on building materials considers the availability of natural stone for various purposes, the geologic nature of raw materials for Portland cement, brick clays, etc. Similar treatment is given the other chapters, which cover "Civil and Structural Engineering," "Coal and Coal Mining," "Ores—Prospecting and Mining," "Mineral Oil (petroleum) and Natural Gas," "Geology and Agriculture," and a few miscellaneous topics. Many specific examples are presented in some detail showing the relationship of geology to the interests of man.

Practically all of the examples given are drawn from the author's experience and associations in the British Isles; the American reader will miss the reality of situations and places familiar to him. Part of the technical terminology and most of the stratigraphic nomenclature are purely British and depart appreciably from America usage; although unfamiliar, it is all comprehensible.

This reviewer was pleased to find a "popular" book on geology that was not "written down" to an audience. It will be informative reading, particularly to those concerned with the physical features of the earth. Unfortunately the high price may prove a deterrent to many.

—Esper S. Larsen, 3rd
U. S. Geological Survey

REFERENCE GUIDE OUTLINE—Specifications for Aerial Surveys and Mapping by Photogrammetric Methods for Highways—1956. Published by the *U. S. Department of Commerce, Bureau of Public Roads,* Washington, D.C. 1956. xxvi and 96 pages. For sale by the Superintendent of Documents, Government Printing Office, Washington 25, D. C.—price 55 cents.

The *Reference Guide Outline* was prepared by the Photogrammetry for Highways Committee, which was under the joint sponsorship of the American Society of Photogrammetry and the American Congress on Surveying and Mapping.

The committee which prepared this publication numbered fifteen recognized authorities on the subject and was under the chairmanship of William T. Pryor, Chief, Aerial Surveys, Bureau of Public Roads.

The *Reference Guide Outline* was first issued "for use in the Bureau of Public Roads" and had a blue cover. Later, the Government Printing Office produced copies for general use, and these may be readily distinguished from the earlier copies by means of their yellow covers. Certain typographical errors were corrected before the later printing. Also a few changes were made to eliminate specific reference to the Bureau of Public Roads or to forms used by that organization.

Coming out at this time, when a great road-building program is to be undertaken, and representing, as it does, the considered opinions of a recognized group of authorities and having the backing of two national organizations vitally concerned, the *Reference Guide Outline* should serve to promote efficiency in planning and carrying on the proposed expansion program for the highway network of the United States.

All concerned in the program or in any similar undertaking, even of much lesser magnitude, would do well to obtain and study carefully these specifications.

—Howard S. Rappleye

CALIBRATION OF LINE STANDARDS OF LENGTH AND MEASURING TAPES AT THE NATIONAL BUREAU OF STANDARDS—National Bureau of Standards Circular 572. Lewis V. Judson. iii and 11 pages, illustrated.

Calibration of Line Standards of Length and Measuring Tapes at the National Bureau of Standards was issued June 4, 1956, and supersedes Circular 328, "Testing of Measuring Tapes at the National Bureau of Standards," and Circular 332, "Testing of Line Standards of Length." It is for sale by the Superintendent of Documents, Government Printing Office, Washington 25, D. C., for 15 cents.

This publication describes the facilities at the National Bureau of Standards for the calibration of line standards of length and measuring tapes submitted for testing. There is some discussion of the considerations which should be taken into account when deciding whether or not to submit items for testing, and instructions are given as to submitting items for calibration.

Of particular interest to surveyors will be the "Appendix—Use of Steel Tapes," in which nomograms and formulas pertaining to variations in the effective length of the tape under varying conditions of temperature, support, and tension are given.

The treatment of the subject "Tension of Accuracy" should be of particular interest to anyone engaged, even infrequently, in accurate layout work.

This reviewer is convinced that no practicing surveyor worthy of his salt should fail to obtain and study carefully this useful and interesting publication.

—Howard S. Rappleye

ROUTE SURVEYING. Carl F. Meyer. *International Textbook Company,* Scranton, Pa., 1955. 312 pages, plus tables. $7.50.

This textbook is an excellent coverage of the basic principles, practical applications, and comprehensive usable tables generally encountered in Route Surveying.

The author has placed his material in a logical order and in a manner that makes the book both usable and understandable for the beginner.

Basic principles involved in location, as well as the fundamentals of simple and compound curves, are complete and teachable. Parabolic curves, spirals, and earthwork are also presented in Part I in a manner adequate for the beginner, as well as a ready reference for the practicing engineer.

Part II deals with practical applications. Special curve problems are treated in detail, along with excellent applications of the usual knotty special situations that arise in highway and railway design. Many types of obstacle problems, as well as relocation, are illustrated.

Sight distance, safe stopping distance, passing requirements, and superelevation are adequately presented. Vertical alignment is well covered, and numerous examples of equal leg and unequal leg vertical curves are given. Sag and high point treatment is excellent.

One chapter is devoted to the treatment of the problems unique to railroad surveys, with special treatment given to string lining.

The development of highway plans and specifications is well covered and numerous practical problems are given to emphasize the subject. Aerial surveys are treated in such a manner as to indicate their value in many location and design problems.

Surveys for other routes are given special treatment in a separate chapter dealing specifically with transmission-line surveys and pipe lines.

Aerial photography as an adjunct to route-surveying methods is treated in a separate chapter, which sets forth the use of mosaics, stereoscopes, planimetric maps, and photogrammetric methods applicable to reconnaissance and detailed location studies. The advantages and shortcomings of the use of photogrammetry are brought out.

The tables are very complete and adequate for nearly any situation that can be found.

On the whole, an excellent book that the teaching profession should accept wholeheartedly.

—C. W. Eshbaugh
Missouri School of Mines and Metallurgy

GLOBES AND SPHERICAL MAPS. Louis H. Powell. *Science Bulletin No. 4, The Science Museum,* St. Paul, Minnesota, 1956. 16 pp.

During World War II, the Science Museum, St. Paul, Minn., used large globes and spherical maps for illustrating and popularizing new concepts in world relationships. These display materials proved to be very effective and many Science Museum exhibits are built around them. Through a manufacturing affiliate the Museum has supplied large globes and globe segments to

various government agencies, schools, and institutions.

The Museum's director, Louis H. Powell, has now published a small booklet describing the spherical maps and globes, and pointing out various ways in which they may be used to advantage. This information should be of particular interest to museum directors, librarians, and others whose work involves the planning and arrangement of effective and dramatic exhibits.

—WALTER W. RISTOW

Library of Congress

Scholarship Announced for Graduate Study in Librarianship

The Scholarship and Student Loan Fund Committee of the Special Libraries Association has announced two $700 scholarships to be granted for the academic year 1957–1958 for graduate study in librarianship leading to a degree at an accredited library school. Applicants must be college graduates of high academic achievement who need financial assistance in obtaining the professional education necessary for work in the special library field.

Application blanks and details of eligibility for the awards may be obtained from the Executive Secretary, Special Libraries Association, 31 East Tenth Street, New York 3, N. Y. Applications must be received by March 1, 1957. The awards will be announced at the annual convention of the Association in Boston, May 1957.

RECENTLY PUBLISHED BOOKS

ROUTE SURVEYING 2d ed.

By CARL F. MEYER, Professor of Civil Engineering, Worcester Polytechnic Institute

This thoroughly-revised standard work on route surveying and design presents up-to-date coverage of basic principles and practical applications. Outstanding features of the new edition are: expansion of the readily usable tables; inclusion of material on applications of photogrammetry to route-location; complete revision of the treatment of curve problems in accordance with the new A.A.S.H.O. Policy on Geometric Design; incorporation of the A.A.S.H.O. Policy notation in the coverage of vertical curves; an expanded treatment of the mass diagram and its applications; and inclusion of a simple traverse solution for the completely-spiraled compound curve. *1956. 630 pages. $7.50.*

ELEMENTARY SURVEYING 3rd ed.

By RUSSELL C. BRINKER, Head, Department of Civil Engineering, Virginia Polytechnic Institute, and WARREN C. TAYLOR, Professor Emeritus of Civil Engineering, Union College

Extensively revised by Professor Brinker, this new edition is completely rewritten and reset. A clear, concise treatment integrates the theory of tape, level, transit, plane table, and new types of equipment with practical instruction for their use. Also covered are specialized topics including: photogrammetry; boundary, public-land, and construction surveys; and industrial applications of surveying methods. *1955. 560 pages. $5.50.*

International Textbook Company • Scranton 9, Pennsylvania

MAP INFORMATION

This department was inaugurated for the purpose of bringing to the attention of the members information pertaining to the availability of maps, surveys, etc., with particular emphasis on how such material can be procured. It is believed that through an interchange and dissemination of such information maximum benefits will accrue to the surveying and mapping profession.

—EDITOR

Topographic Maps

THE FOLLOWING quadrangle maps were published by the U. S. Geological Survey between June 1 and August 31, 1956. The list includes newly compiled maps; revised maps on which contours and drainage usually are unchanged but the works of man are brought up to date; and series-converted maps which are 15-minute maps produced from four 7½-minute maps of the same area. The maps are new unless otherwise designated by numerical superscript.

The quadrangle name (in capital letters) is followed by the name of the county (in upper- and lower-case letters) that contains the place or feature for which the quadrangle is named.

All maps are available with or without the green overprint that indicates woodland. These maps show the shape and elevation of the land surface (represented by contour lines, printed in brown—except those marked with the letter (P), which are planimetric); water features (in blue); works of man, including cities, towns, and scattered habitations, schools, churches, railroads, roads and boundaries, place and feature names (in black); and woodland areas (in green). Principal roads are shown by a red overprint. In areas that have been covered by Bureau of Land Management Surveys, township and section lines are shown. The State rectangular coordinate systems are indicated in the margins of the maps. An information folder further describing topographic maps is available on request.

Standard quadrangle maps may be obtained for 20 cents per copy. A discount of 20 percent is allowed on orders amounting to $10 or more at the retail price. Orders should be addressed to the U. S. Geological Survey, Washington 25, D. C., (or Denver 15, Colo., for maps of areas west of the Mississippi River).

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* Indicates 15-minute quadrangle; all others are 7½-minute quadrangles.
[1] Indicates a revised map.
[2] Indicates a series-converted map.
† Indicates availability in either a contour or shaded relief edition.
‡ Indicates preliminary black and white edition.

Alaska

DILLINGHAM (A-1)*—Third Judicial Division
JUNEAU (A-3)*—First Judicial Division
JUNEAU (B-4)*—First Judicial Division
JUNEAU (B-6)*—First Judicial Division
JUNEAU (C-4)[2]—First Judicial Division
JUNEAU (C-5)*—First Judicial Division
KANTISHNA RIVER (B-4)*—Fourth Judicial Division
KANTISHNA RIVER (C-1)*—Fourth Judicial Division
KARLUK (C-4 and C-5)*—Third Judicial Division
KARLUK (C-6)*—Third Judicial Division
KARLUK (D-4)*—Third Judicial Division
KARLUK (D-5)*—Third Judicial Division
LIVENGOOD (A-6)*—Fourth Judicial Division
MT. KATMAI (A-3)*—Third Judicial Division
MT. KATMAI (A-4)*—Third Judicial Division
MT. KATMAI (B-1)*—Third Judicial Division
MT. KATMAI (B-3)*—Third Judicial Division
MT. KATMAI (B-4)*—Third Judicial Division
MT. KATMAI (D-2)*—Third Judicial Division
MT. KATMAI (D-3)*—Third Judicial Division
MT. KATMAI (D-5)*—Third Judicial Division
MT. KATMAI (D-6)*—Third Judicial Division
NAKNEK (A-1)*—Third Judicial Division

NAKNEK (A-2)*—Third Judicial Division
NAKNEK (A-3)*—Third Judicial Division
NAKNEK (A-4)*—Third Judicial Division
NAKNEK (A-5)*—Third Judicial Division
NAKNEK (B-1)*—Third Judicial Division
NAKNEK (D-1)*—Third Judicial Division
NUSHAGAK BAY (D-5)*—Third Judicial Division
SITKA (B-3)*—First Judicial Division
SITKA (C-7)*—First Judicial Division
SOLOMON (C-6)*—Second Judicial Division
SOLOMON (D-1)*—Second Judicial Division
SOLOMON (D-2)*—Second Judicial Division
SOLOMON (D-3)*—Second Judicial Division
SOLOMON (D-4)*—Second Judicial Division
SOLOMON (D-5)*—Second Judicial Division
SOLOMON (D-6)*—Second Judicial Division
TANANA (A-1)*—Fourth Judicial Division
TANANA (A-2)*—Fourth Judicial Division
TANANA (A-3)*—Fourth Judicial Division
TANANA (A-4)*—Fourth Judicial Division
UGASHIK (B-2)*—Third Judicial Division
UGASHIK (B-3)*—Third Judicial Division
UGASHIK (C-2)*—Third Judicial Division
UGASHIK (C-3)*—Third Judicial Division
UGASHIK (C-4)*—Third Judicial Division
UGASHIK (C-6)*—Third Judicial Division
UGASHIK (D-3)*—Third Judicial Division
UGASHIK (D-4)*—Third Judicial Division

Arizona

EMMETT WASH*—Coconino
GROWLER—Yuma
‡HEATON KNOLLS NW—Mohave
MOON MTN.—Yuma
NANKOWEAP*—Coconino
PARIA PLATEAU*—Coconino
TANNER WASH*—Coconino

Arizona-California

POSTON—Yuma

Arkansas

STRAWBERRY—Lawrence

Arkansas-Missouri

PIGGOTT*[1]—Clay

Arkansas-Tennessee

EVADALE*[1]—Mississippi

California

BROADVIEW FARMS—Fresno
BROADWELL LAKE*—San Bernardino
CADY MOUNTAINS*—San Bernardino
CHANEY RANCH—Fresno
DEADMAN LAKE*[2]—San Bernardino
GILROY—Santa Clara
GUERNEVILLE—Sonoma
JIMTOWN—Sonoma
LAUREL—Santa Cruz
LUDLOW*[2]—San Bernardino
MACDOEL*—Siskiyou
NEWBERRY*—San Bernardino
OPAL MOUNTAIN*—San Bernardino
ORD MOUNTAIN*—San Bernardino
PRUNEDALE—Monterey

California-Nevada

KINGS BEACH—Placer
MEEKS BAY—El Dorado

Colorado

BISHOP RANCH—Bent
GATEVIEW—Gunnison
GRANADA NE—Prowers
GRANADA NW—Prowers
LUBERS—Bent
MAY VALLEY—Prowers
McCLAVE—Butte
MEREDITH HILL—Otero
MOUNT TYNDALL—Custer
ROSITA—Custer
STRASBURG NW—Arapahoe
TREE TOP RANCH—Bent
WATKINS SE—Arapahoe

Connecticut

BRANFORD—Sussex
Kent[1]—Litchfield
Meriden[1]—New Haven
NEW PRESTON[1]—Litchfield
ROXBURY[1]—Litchfield

Delaware

HARBESON—Sussex
FRANKFORD[1]—Sussex
MIDDLETOWN—New Castle
REHOBOTH BEACH—Sussex

Florida

ALTURAS—Polk
BOWLING GREEN—Hardee
ELOISE—Polk
KEYSVILLE—Hillsborough
NICHOLS—Polk
SHADY GROVE—Taylor
SYCAMORE—Gadsden
WACISSA—Jefferson
WITHLACOOCHEE BAY—Levy
WAUKEENAH—Jefferson

Florida-Georgia

COUNCIL—Clinch
FAIRCHILD—Seminole
FARGO SW—Columbia

Georgia

AUSTELL—Cobb
BEN HILL—Fulton
BROAD—Wilkes
JONESBORO—Clayton
LOST MOUNTAIN—Cobb

Hawaii

EWA—Honolulu
KANEOHE—Honolulu
PUULOA—Honolulu

Illinois

BEMENT*—Piatt
BERWYN[1]—Cook
ENGLEWOOD[1]—Cook

Indiana

HALL—Morgan

Kansas

ASSARIA—Saline
CARBONDALE—Osage
GYPSUM—Saline
KIPP—Saline
LINTON—Douglas
OVERBROOK—Osage
RICHLAND—Shawnee
SALINA—Saline
TRENTON—Saline

Kentucky

BROOKS[1]—Bullitt
UNION[1]—Boone
VALLEY STATION[1]—Jefferson

Kentucky-Ohio

BURLINGTON—Boone

Louisiana

ABBEVILLE*—Vermilion
BOSSIER CITY—Bossier
BOSSIER CITY*—Bossier
CALVIN*—Winn
CAMERON*—Cameron
CONSTANCE BAYOU*—Cameron
FORKED ISLAND*—Vermilion
GRAND LAKE EAST*—Cameron
GREENWOOD*—Caddo
HOG BAYOU*—Cameron
MOORINGSPORT*—Caddo
MOSS BLUFF—Calcasieu
NORTH SHREVEPORT—Caddo
OLLA*—LaSalle
OPELOUSAS*—St. Landry

Maryland

NORTHBEACH—Calvert
PRINCE FREDERICK—Calvert

Maryland-Pennsylvania

CLEAR SPRING[1]—Washington

Massachusetts

FITCHBURG[1]—Worcester
GOSHEN[1]—Hampshire
LUDLOW[1]—Hampden
PLAINFIELD[1]—Hampshire

Michigan

KINROSS—Chippewa

Minnesota

LEWISTON*—Winona

Mississippi

BLUE MOUNTAIN*—Tippah
RIPLEY*—Tippah
SAVANNAH*—Pearl River

Missouri

BLAIRSTOWN—Henry
BURTVILLE—Johnson
LEETON—Johnson

Nebraska

WOLBACH—Greeley
WOLBACH NE—Howard

New Jersey

CHESTER[1]—Morris
DOVER[1]—Morris
FRANKLIN[1]—Sussex
GLADSTONE[1]—Somerset
HIGHTSTOWN[1]—Mercer
MENDHAM[1]—Morris
PITTSTOWN[1]—Hunterdon
PRINCETON[1]—Mercer

New Mexico

RED LAKE—Eddy
RED LAKE SE—Eddy
SEVEN RIVERS—Eddy

New York

ALBION*[2]—Orleans
BROCTON—Chautauqua
FORESTVILLE—Chautauqua
GERRY—Chautauqua
GREENLAWN[1]—Suffolk
KENDALL*[2]—Orleans
NORTH OF DUNKIRK—Chautauqua
OLCOTT*[2]—Niagara
PARADOX LAKE*—Essex
PERRYSBURG—Cattaraugus
RIDGEWAY*[2]—Orleans
SCHROON LAKE—Essex
TULLY[1]—Onondaga
VAN ETTEN—Chemung
VOORHEESVILLE—Albany

New York-Connecticut

MT. KISCO—Westchester

NewYork-New Jersey

GREENWOOD LAKE—Orange

New York-Pennsylvania
WAVERLY—Tioga

New York-Vermont
NORTH POWNAL[1]—Bennington

North Carolina
COLUMBIA EAST—Tyrrell
COLUMBIA WEST—Tyrrell
EAST LAKE—Dare
EAST LAKE SE—Dare
ENGELHARD NE—Dare
FORT LANDING—Tyrrell
MANNS HARBOR—Dare
MANTEO—Dare
SCOTIA—Tyrrell
STUMPY POINT—Dare

Ohio
CANAL WINCHESTER—Franklin
CLIFTON—Greene
DONNELSVILLE—Clark
GALENA—Delaware
HILLIARD—Franklin
LEBANON—Warren
NEW BURLINGTON—Clinton
NORTHEAST COLUMBUS—Franklin
NORTHWEST COLUMBUS—Franklin
PORT WILLIAM—Clinton
SUNBURY—Delaware
TIPP CITY—Miami
TROTWOOD—Montgomery
WEST MILTON—Miami
XENIA—Greene
YELLOW SPRINGS—Greene

Oklahoma
BROKEN ARROW—Tulsa

Oregon
BUTTE FALLS*—Jackson
CHETCO PEAK*—Curry
COLLIER BUTTE*—Curry
ESTACADA—Clackamas
HILLSBORO—Washington
MT. EMILY*—Curry
PORT OXFORD*—Curry
POWERS—Coos
SCHOLLS—Washington
SUTHERLIN*—Douglas

Oregon-California
ASHLAND*—Jackson
CAVE JUNCTION*—Josephine
OREGON CAVES*—Josephine
RUCH*—Jackson
TALENT*—Jackson

Oregon-Washington
DEER ISLAND—Columbia

Pennsylvania
AIRVILLE—York
BETHEL—Berks
CLARENDON—Warren
HANOVER—York
KEENEYVILLE—Tioga
MILTON[1]—Northumberland
MINERSVILLE[1]—Schuylkill
MOUNT CARMEL[1]—Northumberland
SEVEN VALLEYS—York
SWATARA HILL[1]—Schuylkill
WAKEFIELD—Lancaster

Pennsylvania-Delaware
KENNETT SQUARE—Chester

Pennsylvania-Delaware-New Jersey
MARCUS HOOK[1]—Delaware

Pennsylvania-New York
RUSSELL—Warren

Puerto Rico
GURABO[1]—Gurabo

Rhode Island
GEORGIAVILLE[1]—Providence

South Dakota
DALZELL—Meade
DALZELL NE—Meade
DALZELL NW—Meade
DALZELL SE—Pennington
SCENIC SW—Pennington
WASTA—Pennington
WASTA NE—Pennington
WASTA NW—Meade

Tennessee
BAXTER—Putnam
FOREST GROVE—Davidson

Tennessee-Kentucky-Virginia
MIDDLESBORO SOUTH—Bell

Texas
AUSTIN*—Travis
BRADY MOUNTAIN—San Saba
MONTOPOLIS*—Travis
PONTOTOC—Mason
PORT INGLESIDE—San Patricio
SINTON*—San Patricio
SMOOTHING IRON MTN.—Llano
VALLEY SPRING—Llano

Utah
ANTELOPE ISLAND NORTH—Davis
BEAR RIVER CITY—Box Elder
‡BEAVER DAM MTS. NE—Washington
‡BEAVER DAM MTS. SE—Washington
CAMELS BACK RIDGE NW—Tooele
‡CARLISLE 1 NE—San Juan
‡CARLISLE 1 NW—San Juan
‡CARLISLE 1 SE—San Juan
‡CARLISLE 1 SW—San Juan
‡CARLISLE 3 NE—San Juan
‡CARLISLE 3 SW—San Juan
‡CARLISLE 4 NE—San Juan
‡CARLISLE 4 NW—San Juan
‡CARLISLE 4 SE—San Juan
‡CARLISLE 4 SW—San Juan
CLEARFIELD—Davis
DUGWAY PROVING GROUNDS NW—Tooele
DUGWAY PROVING GROUNDS SW—Tooele
FLAT CANYON—Carbon
FREMONT ISLAND*—Weber
GRANITE PEAK SE—Tooele
‡LA VERKIN 1 SW—Washington
‡LA VERKIN 2 SE—Washington
‡LA VERKIN 2 SW—Washington
‡LA VERKIN 3 NE—Washington
‡LA VERKIN 3 NW—Washington
‡LA VERKIN 3 SE—Washington
‡LA VERKIN 3 SW—Washington
‡LA VERKIN 4 NW—Washington
‡LA VERKIN 4 SE—Washington
‡LA VERKIN 4 SW—Washington
‡MT. WAAS 2 SE—Grand
OGDEN BAY—Weber
‡ORDERVILLE CANYON NW—Washington
‡ORDERVILLE CANYON SE—Kane
PLAIN CITY—Weber
WILDCAT MTN.—Tooele
WILLARD SPUR—Box Elder

Virgin Islands
CENTRAL ST. THOMAS—St. Thomas
EASTERN ST. THOMAS—St. Thomas
WESTERN ST. THOMAS—St. Thomas

Virginia
CLAY BANK—Gloucester
NORTH BAY—Princess Anne
PLEASANT RIDGE—Princess Anne
SUFFOLF—Nansemond

Virginia-Kentucky
APPALACHIA—Wise
FLAT GAP—Wise
KEOKEE—Lee
PENNINGTON GAP—Lee

Virginia-Maryland
KING GEORGE—King George

Virginia-North Carolina
CREEDS—Princess Anne
KNOTTS ISLAND—Currituck
LAKE DRUMMOND[1]—Norfolk
LAKE DRUMMOND SE—Norfolk

Washington
DEER ISLAND—Columbia
DES MOINES—King
DUWAMISH HEAD—King
KIRKLAND—King
MERCER ISLAND—King
RENTON—King
RIDGEFIELD—Clark
SEATLE NORTH—King
SEATTLE SOUTH—King
SPRAGUE*—Lincoln
VASHON—King

Wisconsin
GRESHAM* (P)—Shawano
MANITOWOC—Manitowoc
MANITOWOC*—Manitowoc
REEDSVILLE*—Manitowoc
SHAWANO* (P)—Shawano
WITTENBERG* (P)—Shawano

Wyoming
BIG JUDSON—Albany
BOSLER—Albany

In addition to the standard series of quadrangle maps, small-scale (1:250,000) maps of areas in the United States and Territories are being published and distributed. Some of these maps are published in a shaded-relief edition, as indicated in the list below. They may be purchased from the Geological Survey for 50 cents per copy. An index to the series is available on request.

Alaska
KAGUYAK†
TELLER†
TRINITY ISLANDS†

Indiana-Michigan-Ohio
FT. WAYNE†

Indiana-Idaho
MUNCIE†

North Dakota
JAMESTOWN†

Texas-Arkansas-Oklahoma-Louisiana
TEXARKANA†

Texas-Louisiana
TYLER†

Special metropolitan-area and vicinity maps of major United States cities are being published and distributed by the Geological Survey. These maps are prepared from stand-

ard 7½-minute maps at the scale of 1:24,000. Vicinity maps may be purchased from the Geological Survey for the prices indicated below. Those published between June 1 and August 31, 1956 are:

CLEVELAND AND VICINITY (50 by 72 inches) $1.50.
DETROIT AND VICINITY (This map comes in two sections, a north and a south half, and is sold as a complete set—46 by 72 inches per section.) $3.00 per complete set.
TOLEDO AND VICINITY (45 by 45 inches) $1.50.
SAN DIEGO AND VICINITY (49 by 70 inches $1.50.

Lake Survey Charts

PUBLICATION of new editions of the following Lake Survey Charts has been announced by the United States Lake Survey of the Corps of Engineers, U. S. Army. Copies of these charts may be obtained from the U. S. Lake Survey, 630 Federal Building, Detroit 26, Mich., at 75 cents per copy. Payment is required in advance by P. O. money order or draft, payable to the Treasurer of the United States.

22.—Coast Chart. Six miles south of Stony Point, N. Y., to 8 miles west of Little Sodus Bay, N. Y., at 1 : 80,000 scale. Inset : Little Sodus Bay, N. Y., at 1 : 15,000 scale. (June 1956.)
25.—Coast Chart. Thirty Mile Point, N. Y., to Port Dalhousie, Ont., including lower Welland Canal, at 1 : 80,000 scale. Insets : Olcott, N. Y., at 1 : 10,000 scale ; Wilson, N. Y., at 1 : 10,000 scale. (June 1956.)
31.—Coast Chart. East end of Lake Erie, Morgans Point, Ont., to Sturgeon Point, N. Y., including Niagara River and Welland Canal, at 1 : 80,000 scale. (June 1956.)
33.—Coast Chart. Thirteen miles east of Erie, Pa., to 7 miles west of Conneaut, Ohio, at 1 : 80,000 scale. Inset : Conneaut, Ohio, at 1 : 10,000 scale. (May 1956.)
43.—St. Clair River, including St. Clair Flats and foot of Lake Huron, at 1 : 40,000 scale. Inset : Head of St. Clair River, at 1 : 15,000 scale. (June 1956.)
113.—St. Lawrence River, Morristown, N. Y., to Union Park, Ont., at 1 : 15,000 scale. (June 1956.)
114.—St. Lawrence River, Union Park Ont., to Ironsides Isl., N. Y., at 1 : 15,000 scale. (June 1956.)
115.—St. Lawrence River, Ironsides Isl., to Bingham Isl., Ont., at 1 : 15,000 scale. (June 1956.)
117.—St. Lawrence River, Round Isl., N. Y., and Gananoque, Ont., to Wolfe Isl., Ont., at 1 : 15,000 scale. (May 1956.)
234.—Sodus Bay, N. Y., at 1 : 10,000 scale. (May 1956.)
238.—Rochester Harbor, N. Y., including Genesee River to head of navigation, at 1 : 10,000 scale. (June 1956.)

Public Land Survey Plats

THE FOLLOWING plats of public land surveys and resurveys were completed and accepted by the Bureau of Land Management between June 1 and August 31, 1956. The class or purpose of the survey is indicated. Copies of plats may be secured from the Bureau Offices in the States or from the Director, Bureau of Land Management, Department of the Interior, Washington 25, D. C.

Arizona—Gila and Salt River Meridian

T. 16 N., R. 2 E.—Extension survey
T. 17 N., R. 2 E.—Resurvey and survey
T. 17 N., R. 3 E.—Resurvey and survey
T. 20 N., R. 15 W.—Mineral segregation survey

California—San Bernardino Meridian

T. 18 N., E. 5 E.—Dependent resurvey and survey
T. 18 N., R. 6 E.—Dependent resurvey and survey
T. 18 N., R. 8 E.—Dependent resurvey of township boundaries

Colorado—Sixth Principal Meridian

T. 2 S., R. 83 W.—Dependent resurvey and survey

Colorado—New Mexico Principal Meridian

T. 47 N., R. 2 E.—Dependent resurvey

Florida—Tallahassee Meridian

Ts. 43 and 44 S., Rs. 20 and 21 E.—Island survey

Idaho—Boise Meridian

T. 12 S., R. 19 E.—Dependent resurvey
T. 12 S., R. 20 E.—Dependent resurvey
T. 12 S., R. 21 E.—Dependent resurvey
T. 11 S., R. 34 E.—Survey of section
T. 15 S., R. 24 E.—Dependent resurvey
T. 16 S., R. 24 E.—Dependent resurvey
T. 6 S., R. 13 E.—Dependent resurvey
T. 13 S., R. 26 E.—Dependent resurvey
T. 14 S., R. 26 E.—Dependent resurvey
T. 15 S., R. 26 E.—Dependent resurvey
T. 13 S., R. 27 E.—Dependent resurvey
T. 14 S., R. 27 E.—Dependent resurvey
T. 13 S., R. 28 E.—Dependent resurvey
T. 14 S., R. 28 E.—Dependent resurvey
T. 11 S., R. 34 E.—Survey

Michigan—Michigan Principal Meridian

T. 19 N., R. 6 E.—Resurvey

Minnesota—Fourth Principal Meridian

T. 56 N., R. 26 W.—Island survey
T. 57 N., R. 26 W.—Island survey
T. 110 N., R. 26 W.—Island survey
T. 58 N., R. 24 W.—Island survey

Nevada—Mt. Diablo Meridian

T. 10 N., R. 21 E.—Dependent resurvey
T. 14 N., R. 60 E.—Dependent and independent resurvey and survey
T. 15 N., R. 60 E.—Dependent and independent resurvey
T. 14 N., R. 61 E.—Dependent and independent resurvey and survey
T 15 N., R. 61 E.—Dependent and independent resurvey

New Mexico—New Mexico Principal Meridian

T. 14 N., R. 1 E.—Survey
T. 14 N., R. 2 E.—Survey
T. 22 N., R. 13 W.—Dependent resurvey
T. 23 N., R. 13 W.—Dependent resurvey

Oregon—Willamette Meridian

T. 29 S., R. 7 W.—Dependent resurvey and subdivision of section
T. 31 S., R. 5 W.—Dependent resurvey
T. 32 S., R. 5 W.—Dependent resurvey

Utah—Salt Lake Meridian

T. 14 S., R. 10 E.—Dependent resurvey and subdivision of section
T. 26 S., R. 22 E.—Resurvey and subdivision of sections

T. 29 S., R. 8 E.—Dependent resurvey and completion survey
T. 21 S., R. 10 E.—Skeleton survey
T. 21 S., R. 11 E.—Skeleton survey
T. 21 S., R. 12 E.—Skeleton survey
T. 22 S., R. 12 E.—Skeleton survey
T. 23 S., R. 12 E.—Skeleton survey
T. 30 S., R. 13 E.—Survey
T. 29 S., R. 14 E.—Completion survey
T. 30 S., R. 14 E.—Survey
T. 23 S., R. 8½ E.—Survey
T. 23 S., R. 9 E.—Survey
T. 24 S., R. 9 E.—Survey
T. 25 S., R. 9 E.—Survey
T. 24 S., R. 8 E.—Survey
T. 25 S., R. 8 E.—Survey
T. 26 S., R. 9 E.—Survey
T. 26 S., R. 6 E.—Dependent resurvey and survey
T. 27 S., R. 6 E.—Survey
T. 28 S., R. 6 E.—Resurvey and survey
T. 26 S., R. 7 E.—Survey
T. 27 S., R. 7 E.—Survey
T. 28 S., R. 7 E.—Resurvey and survey
T. 29 S., R. 7 E.—Survey
T. 27 S., R. 8 E.—Survey
T. 34 S., R. 10 E.—Survey
T. 35 S., R. 10 E.—Survey
T. 34 S., R. 11 E.—Survey
T. 35 S., R. 11 E.—Survey
T. 24 S., R. 10 E.—Skeleton survey
T. 25 S., R. 10 E.—Skeleton survey
T. 24 S., R. 11 E.—Skeleton survey
T. 25 S., R. 11 E.—Skeleton survey
T. 24 S., R. 12 E.—Skeleton survey
T. 33 S., R. 8 E.—Skeleton survey
T. 34 S., R. 8 E.—Skeleton survey
T. 35 S., R. 8 E.—Skeleton survey
T. 33 S., R. 9 E.—Skeleton survey
T. 34 S., R. 9 E.—Skeleton survey
T. 35 S., R. 9 E.—Skeleton survey
T. 33 S., R. 13 E.—Skeleton survey
T. 35½ S., R. 13 E.—Skeleton survey
T. 33 S., R. 14 E.—Skeleton survey
T. 35 S., R. 14 E.—Skeleton survey
T. 33 S., R. 15 E.—Skeleton survey
T. 34 S., R. 15 E.—Skeleton survey
T. 35 S., R. 15 E.—Skeleton survey
T. 33 S., R. 16 E.—Skeleton survey
T. 34 S., R. 16 E.—Skeleton survey
T. 35 S., R. 16 E.—Skeleton survey

Washington—Willamette Meridian

T. 34 N., R. 2 W.—Dependent resurvey and subdivision of sections

Wyoming—Sixth Principal Meridian

T. 41 N., R. 76 W.—Dependent resurvey
T. 42 N., R. 76 W.—Dependent resurvey
T. 41 N., R. 77 W.—Dependent resurvey
T. 42 N., R. 77 W.—Dependent resurvey
T. 43 N., R. 78 W.—Dependent resurvey

Foreign Topographic Mapping Agencies and their Sales and Information Offices

VALID NAMES and addresses of the governmental topographic mapping agencies and sales counters of the following nations may be found listed in SURVEYING AND MAPPING, Vol. XVI, No. 2, pp. 212–216:

Argentina, Australia, Belgium, Ceylon, Costa Rica, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Finland, France, Great Britain, Greece, Guatemala, Honduras, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Panama, Philippines, Poland, Sweden, Switzerland, Syria, Turkey, Union of South Africa, Venezuela, West Germany, Yugoslavia.

Typographical errors in the list published in SURVEYING AND MAPPING, Vol. XVI, No. 2, now stand corrected to read as follows:

MAP SALES AND INFORMATION COUNTERS	GOVERNMENT TOPOGRAPHIC MAP AGENCIES
AUSTRIA Bundesamt fuer Eich- und Vermessungswesen (Landesaufnahme) Krotenthallergasse 3 WIEN VIII	Same
CANADA Map Distribution Office Department of Mines and Technical Surveys OTTAWA, Ontario	Surveys and Mapping Branch Department of Mines and Technical Surveys OTTAWA, Ontario Army Service Establishment Department of National Defense OTTAWA, Ontario
COLOMBIA, S.A. Instituto Geográfico de Colombia "Augustín Codazzi" BOGOTA	Same

HAITI Service de Géodésie & de Cartographie Boulevard Harry Truman Cité de l'Exposition PORT-AU-PRINCE	Same

Current additions to the list are as follows:

BRAZIL Instituto Brasileiro de Geografia e Estatística Conselho Nacional de Geografia Avenida Beira Mar, 436 RIO DE JANEIRO, D.F.	Same
BURMA Director of Survey Burma Survey Department 460 Merchant Street RANGOON	Same
CAMBODIA Service Géographique National du Cambodge PHNOM-PENH	Same
INDIA The Head Clerk, Map Sales Section Survey of India Block No. 9, Room 348 Old Supply Dept. Building Shahjahan Road NEW DELHI-2	Survey of India Hathibarkala DEHRA DUN (U.P.)
also regionally:	
Director, Map Publication Survey of India Hathibarkala DEHRA DUN (U.P.)	Same
Director, Eastern Circle Survey of India 13, Wood Street CALCUTTA-16	Same
Director, Southern Circle Survey of India BANGALORE	Same
LIBERIA Bureau of Mines and Geology Treasury Department of the Republic of Liberia MONROVIA	Same
LIECHTENSTEIN Liechtensteinischer Schulbücherverlag VADUZ	None (*A complete mapping program was executed by the Abteilung für Landestopographie of Switzerland, so commissioned by the Liechtenstein Government.*)
MEXICO Oficina de Geografía Dirección de Geografía y Meteorologia Avenida Observatorio #192 TACUBAYA, D.F.	Same

PORTUGAL	
Livraria Augusto Sá da Costa Rua Garret, 100 LISBOA	Instituto Geográfico e Cadastral Praça de Estrela LISBOA
For itinerary and military maps	
Serviços Cartograficos do Exército Avenida Duque de Loulé, 106 LISBOA	Same
THAILAND	
Quartermaster of the Central Division The Survey Department BANGKOK	Same

—WILLIAM HANNAH

George William Watts

The mapping and surveying profession suffered an irreparable loss in the recent death in London, England, of one of its long-time members, George William Watts. Mr. Watts was the son of Edwin R. Watts who founded E. R. Watts & Son Ltd. ninety-nine years ago. He was eighty-three at the time of his death and had been with the company for nearly seventy years.

Mr. Watts is well known for the design and construction of a precision circular dividing engine. This engine, which was completed in 1905, is still working and will for many years to come serve as a useful memorial to George Watts' skill, craftsmanship, and patience.

A New Research Award

A new award in engineering education, to recognize the research potential and accomplishment of young workers engaged in engineering research in colleges or universities, will be given for the first time in June 1957.

The Engineering College Research Council of the American Society for Engineering Education has announced plans for the Curtis W. McGraw Research Award, established in memory of the late Curtis W. McGraw, president of the McGraw-Hill Publishing Company from February 1950 to September 1953, and brother of the present president, Donald C. McGraw. The award, sponsored by the McGraw-Hill Book Company, will include a cash prize of $1,000 and will be given annually beginning next June.

Candidates are to be young men "who have made original contributions in engineering research and who have demonstrated high potential for future leadership."

In announcing the new award, Raymond J. Woodrow of Princeton University, Chairman of the Engineering College Research Council, pointed out that it is the second major award in engineering college research administered by the American Society for Engineering Education through the Council. The Vincent Bendix Research Award, for contributions to the development of research activities and their management, was first made last June to Dr. Clifford C. Furnas, Chancellor of the University of Buffalo and Assistant Secretary of Defense for Research and Development.

"The development of these two awards," said Dr. Woodrow, "serves to emphasize the growing importance of basic research as a part of engineering education. Both teachers and their students benefit from their participation in active research undertakings on their campuses. Indeed, this kind of research is our best assurance that today's engineering students will graduate well equipped to meet tomorrow's needs."

The recipient of the McGraw Research Award will be selected each year by a special committee of the Engineering College Research Council; Dean James R. Cudworth of the University of Alabama is chairman of this year's selection committee.

The first presentation of the McGraw Research Award will be at the 1957 annual meeting of the American Society for Engineering Education, at Cornell University from June 17 to 21. Nominations for 1957 should reach Dean Cudworth by February 1, 1957.

Comment and Discussion

The pages of SURVEYING AND MAPPING are open to a free and temperate discussion of all matters pertaining to the interests of the CONGRESS. It is the purpose of this Department to encourage comments on published material or the presentation of new ideas in an informal way.
—EDITOR

SQUARE ROOT

J. BOYLE*—Mr. Serge A. Emery (SURVEYING AND MAPPING, October–December 1955, page 490) would be interested in Barlow's Tables of Squares, Cubes, Square Roots, Cube Roots, and Reciprocals of all integer numbers up to 12,500, edited by L. J. Comrie, M.A., Ph.D. London: E. and F.N. Spon Ltd., 57 Haymarket S.W.1.

The square roots of numbers from 1,000 to 9,999 are given to 6 decimal places (8 significant figures) others to 9 significant figures; with differences.

Another book which can be very useful to surveyors, especially when away from a machine, but which seems to be little known, is McAulay's 5-figure Logarithmic and Other Tables; size $3\frac{5}{8} \times 5\frac{1}{2}$ inches. The complete set of proportional parts saves enormous labour when interpolating to seconds. London: Macmillan & Co. Ltd., St. Martin's Street.

Among other uses, these two together are very helpful for quick calculation of radiations in setting out.

* Chief Surveyor, Department of the Interior, Canberra, A.C.T.

PROPOSED SURVEYING AND MAPPING BILL FOR KANSAS

W. C. WYATT*.—I note publication of your letter in the July–September issue of SURVEYING AND MAPPING.

The legislative committee of the Kansas State Board of Engineering Examiners has considered a proposed Surveying and Mapping Bill and, according to Warden Noe, attorney, it is ready to be presented to a proper committee of the legislature when it convenes next January.

All the information I have is that the Kansas Engineering Society is in accordance with the proposal.

A good, sound, and workable Surveying and Mapping Law is definitely needed in the State —one which will protect the welfare of the individual owner-operator as well as the large firms.

If this proposed law does this as presented, I think all proper effort should be made to push the Bill.

I am therefore informing you of the status of this Bill.

* Letter to Chairman, Public Relations Committee, ACSM, from the Secretary-Treasurer, Kansas Council of Engineers and Architects, University of Kansas, Lawrence, Kans.

SQUARE-ROOT-ACRE SCALE

B. R. GILCHRIST*.—I refer to the article on page 398 of the July–September issue of SURVEYING AND MAPPING. The article titled "A $\sqrt{\text{Acre}}$ Scale" was submitted by R. L. Williams of the Cartographic Laboratory, Yale University.

Instead of bringing another bastard (unit) into the world, it is suggested that use be made of an accepted unit of length, called a "chain," which is equivalent to 66 feet, 4 rods, 100 links —or 20.11684 meters.

The utility of the chain as a unit of length results from the fact that 10 square chains are equal to one acre. Thus, an area measured in square chains may be converted to area in acres, simply, by moving a decimal point one place to the left. Using, for an example, a section of one square mile—80 chains on all sides—the computation is as follows: $80.0 \times 80.0 = 6400.00$ square chains or 640.000 acres.

* Ohio River Division, Corps of Engineers, U. S. Army, Box 1159, Cincinnati 1, Ohio.

SURVEYING EDUCATION

DAVID H. DAVIS*.—The part of the forum "What Teachers of Surveying are Doing Right —and Wrong" on which I wish to comment was included in the paper by Mr. Clarke and dealt with the subjects leading to a B.S. degree in Land Surveying in New Zealand and Australia. Such a course is much needed in this country. I, personally, would be interested, if there were an extension program.

Listed with the courses were Physics, Survey Law, Geology, and three others which I think of as being very closely related; Land Utilization, Land Valuation, and Town Planning.

If my own (full time, private) practice is any indication and had I been able to take such a course, I would now feel that the time spent on Physics should have been cut to one half or one third, with a sharp increase in the time devoted to some of the others.

For example, I would have liked at least double the time allotted to Survey Law and liberal additions to the time spent on Utilization, Valuation, and Planning. Additional time in Geology would not have been wasted.

In addition, I feel that a course covering Bookkeeping, Business English, and allied material would have been of great value, since there are many surveyors who are, as I am, pretty much a one-man show. These things are then of much value and should be dealt with.

* Surveyor, 216 Trumbull Parkway, Batavia, N. Y.

Mrs. Charles R. Herr

The ACSM sincerely regrets to report the passing of Mrs. Charles R. Herr, wife of C. R. Herr, Past-Chairman of the Southern California Section of ACSM. Mrs. Herr's death occurred while she and her husband were on their long-planned tour of Europe.

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News of Related Organizations

Wisconsin Society of Land Surveyors

The annual, all-day, summer meeting of the Wisconsin Society of Land Surveyors was held on Sunday, August 5, at Menominee Park in Oshkosh. President James Lange of Beaver Dam called the meeting together with 22 members present.

The morning session was taken up with various committee reports. Robert Poss, Chairman of the Legislative Committee, outlined the status of proposed legislation in the county-surveyor field and led a discussion of the recently revised plotting law.

Prof. Leonard Hillis of the Program Committee distributed tentative programs for the Eighth Surveyor's Institute to be held at the University of Wisconsin.

Franklin P. Gould, Chairman of the Fees, Salaries, Ethics, and Practices Committee, reported that progress had been made in assembling data prerequisite to preparing a code of ethics and a schedule of minimum fees.

Harold T. Arpin of the Apprentice Division of the State Industrial Commission reviewed for the members that section of the recently enacted surveyor registration act which deals with registration after serving an approved apprenticeship. He pointed out that no program for apprenticeship had yet been established. President Lange appointed a five-man special committee to assist the Industrial Commission in setting up this program.

After a recess at noon for a picnic lunch, the meeting convened in informal session for a brief discussion of surveying problems. One of the main items of discussion was the section of the new platting law which allows filing of a survey map with the register of deeds rather than a lengthy metes and bounds description. This method of conveyancing was well received by those present, but several members had experienced difficulty in trying to present the necessary data on a map of the specified small size.

The Board of Direction has voted to increase annual dues from $5 to $7 and recommended an additional increase to $10 in 1958 in order to provide funds for future legislative endeavors and for eventual publication of the Code of Ethics and the Schedule of Minimum Fees.

Georgia Association of Registered Land Surveyors

From the September 1956 issue of *Field Notes,* the monthly publication of the Georgia Association of Registered Land Surveyors, capably edited and distributed by Secretary-Treasurer J. Harold Smith, we learn that there are now 1,087 registered land surveyors in the State of Georgia. (Less than 40 of these are members of ACSM.—Editor)

This issue also reports that two cases of improper surveying practice have recently been referred to the Georgia State Board of Examiners and that a full-fledged investigation was made in one of these instances. This action is welcomed by most surveyors of the State. In the words of Mr. Smith: "If the State Board of Examiners and the Georgia Association of Registered Land Surveyors are to mean anything . . . and if they are to continue to hold a position of high regard . . . it becomes a must that certain standards be enforced and maintained by the State Board and by the *GARLS*. A gradual rise in the standards of practice . . . and more enforcement to maintain the standards would prove healthy for all men in this field."

CONGRESS NEWS

Election of Officers for 1957

Under the provisions of ACSM Constitution and Bylaws, in Executive Session on May 15, 1956, President Higbee named the following ACSM Nominating Committee; Helmuth Bay, Frank S. Borden, with Gerald FitzGerald as chairman and Walter S. Dix, member ex officio, acting secretary to the committee. Continuing deliberations through August, candidates were officially nominated during September, and the ACSM Nominating Committee hereby present and introduce the following candidates accepting nomination and responsibility of office if elected by ballot of the membership for the coming year.

For President (one year term)

ROBERT H. LYDDAN, Washington, D. C.

For Vice President (one year term)

WILLFRED B. WILLIAMS, Grand Rapids, Mich.

For Directors, 1957–58 (Five to be elected for two-year terms)

LOREN A. BLOOM
WARREN C. CRUMP
CHARLES H. DAVEY
ROBERT C. ELLER
I. E. RITTENBERG
JACOB SKOP
ROBERT J. VOSKUIL

Ballots are scheduled to be mailed to the membership during the final quarter of 1956 so that election results may be announced as early as possible in the new year. Actual induction of new officers will take place during the 17th Annual Meeting in March 1957, the incumbent officers remaining in office until that time.

Brief biographies of the candidates follow:

ROBERT H. LYDDAN

Mr. Lyddan was born in Irvington, Ky., December 3, 1910; graduated from the University of Kentucky as a civil engineer in 1931; served with the Interstate Commerce Commission from 1931 to 1933; and then joined the Geological Survey. Until 1946 he was engaged in a variety of topographic mapping activities at several different locations in the United States, Alaska, and Puerto Rico.

From 1946 to 1955 Mr. Lyddan served as the chief of the Planning Branch of the Geological Survey's Topographic Division. From 1955 to 1956 he was in charge of the Survey's Atlantic Region, with headquarters in Arlington, Va. In May 1956 he was made Assistant Director of the Geological Survey.

Mr. Lyddan has served ACSM as a director, 1952–53 and 1955–56; as a member of the Executive Committee; and as deputy chairman of the Professional Status Committee. He is ACSM representative to the Division of Earth Sciences of the National Research Council. He was also chairman of the Surveying and Mapping Division of the American Society of Civil Engineers, 1953–55; a director of the Washington Society of Engineers, 1951–52; and is a member of the American Society of Photogrammetry and the Society of American Military Engineers.

WILLFRED B. WILLIAMS

Mr. Williams was born in Grand Rapids, Mich., and has lived in that city throughout his entire life. He graduated (B.S.) from Michigan State College in 1921; received the C.E. degree from the same school in 1931; holds registration in Michigan both as a land surveyor and as a civil engineer; and has been County Surveyor of Kent County since 1939, when he succeeded his father who had held the same office since 1892.

In 1924 the father and son and two others incorporated their private practice under the name of Williams and Works. They have been active in all phases of land surveying, mapping, property development, sanitary engineering, and highway engineering since that date, primarily in western Michigan. W. B. Williams has been president of the organization since 1931. His son, Ted, (R.L.S. and P.E.) is also an officer, and his grandson shows inclinations to follow the same trail.

"Bill" is Vice President of the Michigan Title Company, a Past President of the Michigan Society of Registered Land Surveyors, a

Director of the Michigan Engineering Society, and has been a member of ACSM since 1949. He is a member of the ACSM Advisory Committee and preceded Gordon Ainsworth as Chairman of the Property Surveys Division.

LOREN A. BLOOM

Loren A. Bloom was born at Chicago City, Minn., October 29, 1907. He attended Kansas University, majoring in aeronautical engineering. A short career in aircraft design and stress analysis ended with the depression. His civil service career began in August 1930 with the Corps of Engineers. He spent two years with the Kansas City District Engineer Office on photogrammetric mapping of the Missouri River. In 1932 Mr. Bloom was transferred to the St. Louis District Engineer Office to work on the photogrammetric mapping of the Mississippi and Illinois Rivers and associated surveys in connection with land acquisition for these waterways.

In 1941 Mr. Bloom transferred to Headquarters Army Air Corps, where the project became one of developing aeronautical charts to meet the requirements of a global war. From this office in Headquarters AAF was formed the USAF Aeronautical Chart Service where Mr. Bloom served as Technical Advisor to the Commander from 1943–52. He was then transferred to Headquarters USAF and is now Chief of Cartography in the Photo and Cartography Branch, as well as Technical Advisor to the Director of Operations, Headquarters, USAF.

Mr. Bloom is a member of the American Society for Photogrammetry, Institute of Navigation, American Geophysical Union, and ACSM.

WARREN C. CRUMP

Warren C. Crump, since 1943, has been Deputy Director of the Technical and Production Department of the U. S. Navy Hydrographic Office, with which office he has been associated as Cartographer since 1920. A graduate of George Washington University, with a degree in civil engineering in 1940, he continued postgraduate studies during 1941–44 at the same school under War Training Programs in science, education, and management.

He is a member of Theta Tau, Sigma Tau, and Omicron Delta Kappa, and is also active in alumni activities, being President, G. W. U. Engineer Alumni Association, member Alumni Board of Control, and Alumni representative in the U. S. Navy Hydrographic Office.

He is a member of the American Society of Photogrammetry, the Washington Litho Club, and has actively served ACSM as Chairman, Cartography Division, 1949–50; member of the Publications Committee, 1948–50; and Vice President, 1951.

CHARLES H. DAVEY

Charles H. Davey graduated from Syracuse University in 1913 with the degree of Civil Engineer. He was appointed a Junior Topographer in the Geological Survey in 1912 and was assigned to topographic field surveys from 1912–17 and from 1912–33. During World War I he was a captain in the 29th Engineers, A.E.F., 1918–19. In 1920–21 he was an assistant engineer with the New York Water Power Investigation.

From 1933–35 and 1937–42 he was Section Chief, Topographic Division, USGS, in charge of topographic surveys in New England. In 1936 he was in charge of completion of the planimetric mapping program of the Tennessee Valley Authority, and from 1943–46 was Chief, Section of Photogrammetry, USGS. In 1947 he became Chief, Topographic Surveys Section, Research and Technical Control Staff Branch, holding this position until May 1956 when he became Atlantic Region Engineer, USGS.

Mr. Davey is a charter member of the American Society of Photogrammetry, a member of the Washington Society of Engineers, and has served ACSM from 1950–54 as ACSM's first representative to the National Research Council of the National Academy of Sciences.

ROBERT C. ELLER

Robert C. Eller was born in Spokane, Wash., and attended schools there and in western Montana. He majored in chemical engineering at Spokane Valley Junior College and at Washington State College. Mr. Eller practically grew up in the surveying profession: his father was for many years the County Surveyor of Mineral County, Mont. He served as Deputy County Surveyor for a short period before accepting a position with the U. S. Geological Survey in Washington, D. C., in 1942. He has been with the Survey since that time and is now Chief, Planimetric Compilation Section, Special Maps Branch, Topographic Division.

Mr. Eller served as Assistant Editor of SURVEYING AND MAPPING in 1952 and as Editor-in-Chief from 1953–55.

I. E. RITTENBERG

Captain Isidor E. Rittenberg, Assistant Director for Administration, Coast and Geodetic Survey, since September 1952, was born in Boston, Mass., February 5, 1901. He graduated from Tufts College in 1923 with a degree in civil engineering and immediately entered on duty with the Coast and Geodetic Survey. He has devoted his entire professional career to the Survey, where he has made progressive advancement from Ensign to Captain.

Captain Rittenberg has made important contributions in the field of hydrographic and geodetic surveying; his field assignments have included surveys along the Atlantic and Pacific coasts of the United States and in Alaska and the Philippines; he has served as navigator, executive officer, and commanding officer on various survey ships of the Bureau; and prior to assuming his present duties he was Assistant Chief, Division of Coastal Surveys. He has also served as Chief, Nautical Chart Branch and as Assistant Chief, Division of Charts.

He is a member of the Institute of Navigation, the Society of American Military Engineers, the American Geophysical Union, and ACSM.

JACOB SKOP

Jacob Skop was born in Baltimore, Md., November 11, 1906. He attended both Rhode Island State College and the University of Maryland. He joined the Army Map Service in June 1938 and has had increasingly responsible assignments through his service with that organization.

In January 1941, he organized AMS Map Editing; in June 1943, he became Chief of Map Design; and has served as Chairman of the Joint Mapping and Photographic Subcommittee, which standardized map symbolization and basic specifications used by Federal mapping agencies in preparing large- and medium-scale maps. He served as U. S. Army technical representative in the Canada-Britain-United States Army Map Standardization Proceedings, and later served in a similar capacity in NATO map standardization. In 1951–52 he served as AMS Liaison Officer in Europe. He is now Chief, User Requirements Division, AMS.

Mr. Skop is the author of numerous articles which have appeared in various domestic and foreign journals devoted to surveying and mapping. He is a member of the American Society of Photogrammetry and the Society of American Military Engineers. His service to ACSM includes a tour of duty as member of the Publications Committee; Chairman, Program Committee for the 1954 Annual Meeting; and he was one of the organizers of and a director of the Topography Division.

ROBERT J. VOSKUIL

Robert J. Voskuil has been a professional cartographer with the United States Government for the past 15 years. He served as chairman, Cartographic Division, ACSM in 1951 and is currently a Director of that Division. He has attended several international cartographic conferences, is a member of the United States Board of Geographic Names, and has concentrated his efforts in the field of special maps. Prior to government service he taught Geography at Syracuse University and at the University of Illinois, having had formal training in that field at both undergraduate and graduate levels.

He is a member of the Association of American Geographers and is currently representing the interests of ACSM on the Cartographic Committee of that organization.

Northern California Section

The Northern California Section held a very successful meeting in Sacramento on October 5, 1956, with "open house" at both the Geological Survey and Bureau of Land Management offices. At the formal meeting in the evening, a surprise visit by our National President, Lester C. Higbee, climaxed the day's activities.

The Bureau of Land Management had an exhibit of various types of monuments—from stones to galvanized pipes capped with bronze disks. The files were open to show filing and indexing systems; original field notes and plats were on display; and explanations of procedures for obtaining data were given by the office personnel, under the direction of Cadastral Engineer George F. Tyrrell. Visitors to the office were fortunate in having the opportunity of meeting Earl G. Harrington, Cadastral Engineering Staff Officer to the Director of the Bureau of Land Management, who happened to be here from his Washington, D. C. office.

Approximately three hundred visitors to the U. S. Geological Survey offices were welcomed

at the door by guides who conducted them on tours to see demonstrations and hear talks on various phases of the procedures followed in photogrammetry, field surveys, cartography, conservation, and water resources. As usual the Geological Survey personnel were well qualified for their assigned tasks, and the visitors left the offices with a great deal of information and a better understanding of the functional operations involved in the preparation of a modern U. S. Geological Survey quadrangle sheet.

A GEODIMETER was also on display and was demonstrated by Milton E. Compton, of Berg, Hedstrom & Co., Inc. The measuring of 20-mile base lines to an accuracy of four inches and higher degrees of precision brought out a lot of questions from the bystanders, which were very ably answered by Mr. Compton.

At the formal evening meeting, the first paper was given by Mr. Tyrrell of the Bureau of Land Management. He reviewed the establishment of the land-office surveys in California and the present practices of cadastral engineering in that Bureau. This paper was so well prepared that, at the end of the meeting, Mr. Tyrrell was swamped with requests for copies of the paper. Mr. Harrington of the Washington office of the Bureau assisted Mr. Tyrrell in answering questions from the floor relative to cadastral engineering practices.

The second item on the agenda was the presentation of a color motion picture and a talk by Milton E. Compton on the GEODIMETER. Mr. Compton, even after a very busy day of explaining and demonstrating this new and accurate distance-measuring device, again had the GEODIMETER on display and answered questions from the floor.

Climaxing the evening was a surprise visit from Lester C. Higbee. Mr. Higbee was not scheduled to arrive in the San Francisco Bay area until Sunday, October 7th, but, when he learned of the Sacramento meeting, he made special arrangements and flew directly from Seattle to Sacramento, arriving about midway of the meeting. Robert O. Davis, newly appointed Pacific Region Engineer, USGS, introduced Mr. Higbee who then gave a brief report on the Fall Convention and Co-Exhibit of the American Society of Photogrammetry and the American Congress on Surveying and Mapping in Denver, Colo. Mr. Higbee also told of the activities of the national organization and praised its officers for the vast amount of work they are doing. He urged that we continue to get more members; that we place ourselves before the public in a professional manner; and that we encourage further education in the sciences of surveying and mapping.

Vernon S. Seward, Past Chairman of the Northern California Section, was the program chairman for this meeting, and he was given a vote of thanks for his efforts in making it the big success it was.

—HARLEY A. WATERFALL
Acting Chairman

Surveyors' Day

The historic college of William and Mary announced, during October 1956, plans for a special "Surveyors' Day" next year as a feature of its participation in the elaborate 1957 Jamestown Festival.

"In view of William and Mary's role in the early days of American surveying," said William and Mary President Alvin Duke Chandler's announcement, "it is altogether fitting and proper that, as America looks back 350 years to the first permanent English settlement at Jamestown, the College should take the lead in setting aside a special observance in honor of the surveying profession and the important role surveying has played in the development of the nation."

It was from William and Mary that George Washington in 1749 received his first public office—a license to practice surveying. He was appointed County Surveyor of Culpeper County at the age of 17 by William and Mary.

At that time, the College was Surveyor-General of the Colony of Virginia, and the William and Mary faculty was entrusted with the duty of examining and licensing surveyors.

In addition, according to Librarian Emeritus Dr. Earl Gregg Swem, members of William and Mary faculty served on a number of important boundary-survey commissions during the colonial period.

"The relationship of the College to surveying in the colonies was a particularly close one," noted Dr. Swem, "and this is a timely occasion for us to emphasize, not only the important role William and Mary played in colonial times, but also the importance of the surveying profession to the world today."

Dr. John T. Baldwin, Jr., director of William

and Mary's participation in the Jamestown Festival, said that plans are already being formulated in cooperation with national surveying officials. The observance is scheduled for August 23, 1957.

Cooperating with the college in planning for "Surveyors' Day" are the American Congress on Surveying and Mapping and the Virginia Association of Surveyors.

At a meeting held recently at the College, representatives of the participating organizations decided to base the theme of the celebration on the "History of Surveying in the United States."

Present at the Williamsburg meeting were John Marshall of Arlington, Va., Vice President of the Virginia Association of Surveyors; R. V. Carter of Williamsburg, Va., Past President of the VAS and chairman of the VAS Surveyors' Day Committee; Howard S. Rappleye of Washington, D.C., Editor-in-Chief of SURVEYING AND MAPPING, the official quarterly journal of the American Congress on Surveying and Mapping; Victor H. Ghent of Annandale, Va., Secretary of the Property Surveys Division of the ACSM; Herbert Ganter, William and Mary Archivist; and Dr. Baldwin.

"Surveyors' Day" is but one of a number of special days William and Mary is planning for the Festival Year. Others will be focused on ceratin key figures who made special contributions to the College and the Nation during the early years in the institution.

William and Mary was established by Royal Charter in 1693, 86 years later than and seven miles inland from where Captain John Smith and the first English settlers landed at Jamestown in 1607.

PLANNING FOR "SURVEYORS' DAY"

Mapping plans for a special "Surveyors' Day" to be held next summer at the College of William and Mary are (left to right) Howard S. Rappleye of Washington, D. C.; Dr. John T. Baldwin, Jr., of the College of William and Mary; John Marshall of Arlington, Va.; R. V. Carter of Williamsburg, Va.; and Victor H. Ghent of Annandale, Va. " Surveyors' Day" will be a special observance in connection with the 1956 Jamestown Festival.

Texas Section

Forty members and guests were present when Chairman J. A. Tomlinson opened the twenty-second meeting of the Texas Section at the Hospitality House in Houston on the evening of October 12, 1956.

After a report by Treasurer Tom Dillon, informing those assembled that the Texas Section now has 185 paid-up members, Chairman Tomlinson reported on the joint meeting of ASP and ACSM local sections at Denver. He said

that a similar meeting will probably be held at St. Louis next year.

J. S. Boyles reported the progress being made by the Commemorative Stamp Committee. He stated that present plans are to work toward the issuance of the stamp during the 350th-anniversary celebration of the founding of Jamestown during the summer of 1957. The College of William and Mary, which is working with ACSM toward issuance of the stamp, has designated one day during the celebration as Surveyors' Day. It is hoped that the stamp can be issued on that day. The Texas Section surveyors are working on the design of the stamp which will commemorate the surveying profession.

Mr. Boyles reported that 1,007 surveyors are now registered as land surveyors in Texas, of which 330 are registered as engineers as well.

Florian E. Davatz, Executive Vice President of the Kern Instrument Co. of White Plains, N. Y. was introduced as the principal speaker by R. L. Sargent. Mr. Davatz spoke on "The History of Optical Instruments and Demonstration of Late Developments." He gave credit for the incorporation of optical systems in surveying instruments to Dr. Henry Wild, who early recognized the necessity of improving upon such instruments as the compass. The superficial similarity of many European instruments, Mr. Davatz said, is due in part to the early inventions of Dr. Wild and to the expiration of his early patents on them. Mr. Davatz outlined the fundamental requirements of a good instrument and traced the history of efforts to satisfy these requirements.

Following the adjournment of the meeting, an opportunity was presented for members and guests to inspect the equipment on display and to enjoy a social session.

—Hodge E. Mason
Editor, Texas Section

Personals

Announcement was made October 12, 1956, of the appointment of **Otto G. J. Schaler** as assistant to H. Walton Cloke, public relations coordinator for Kaiser Industries Corporation. Mr. Schaler is a graduate of George Washington University and the University of Virginia School of Military Government. He also studied law at George Washington University and was Chief, Information Division, Legal Section, Supreme Commander for the Allied Powers in Tokyo after World War II.

Michael Baker, Jr., announces the purchase of the J. Murray Africe Company of Huntington, Pa., which will be continued as a division of Michael Baker, Jr., Inc., Rochester, Pa.

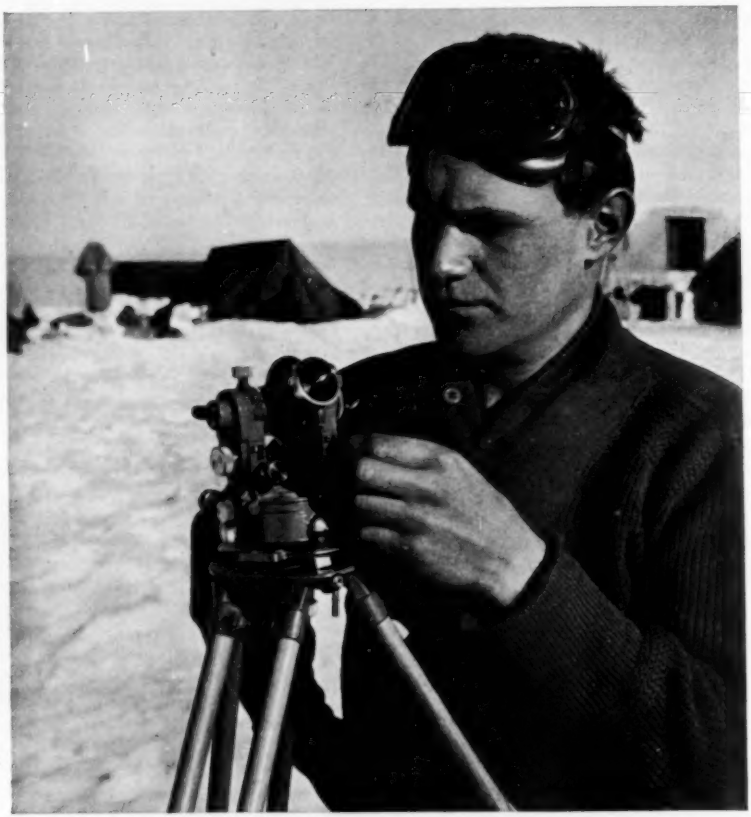
Col. **F. T. Norcross,** President of Associated Engineers, Inc., Washington, D. C., has been retained as planning consultant for the Thorncliff Park development in Toronto, Ontario, Canada.

Professor **Paul Hartman** has been elected chairman of the Department of Civil Engineering of the College of the City of New York.

Harold R. Edmonston, Chief, Nautical Chart Branch, Coast and Geodetic Survey, retired October 31, 1956, after 36 years service with the Survey. During World War I, he served with the 472nd Engineers, specializing in the production of relief maps. Then, after a short period with the New Jersey Zinc Company, he was appointed to a position in the Coast and Geodetic Survey. He was assistant to the chief draftsman in the Manila Field Station until 1924. Gradually taking on positions of greater responsibility, he became Chief, Nautical Chart Branch on January 1, 1949. The Edmonstons will live in Fort Lauderdale, Fla.

William F. Childs, Jr., retired from the Maryland State Roads Commission on October 1, 1956, and is now a consultant with the firm of Whitman, Requardt and Associates, 1304 St. Paul St., Baltimore 2, Maryland.

Retiring Treasurer **Richard T. Evans** is to be succeeded by Captain **Henry W. Hemple** who was appointed by President Higbee, following nomination in Executive Committee meeting in Washington, D.C., November 8, 1956. The new treasurer will gradually take over from Treasurer Evans during the month of December to assume full responsibility by the new year. Major Evans will retain active charge of Library Memberships, subscriptions to the Journal, and related matters. Captain Hemple, formerly Chief, Division of Geodesy, Coast and Geodetic Survey, has previously served ACSM as Chairman of its Control Surveys Division. In accepting Major Evans' formal resignation, President Higbee said, "Words cannot fully express our appreciation of his voluntary efforts in the service of ACSM over these many years."



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NEW MEMBERS

INDIVIDUAL MEMBERSHIPS

ALBRECHT, Edwin A., 109 S. Royal St., Alexandria, Va.—Land Surveyor, Albrecht, Patterson and Associates

ANASTASSIADIS, T. D., 261 W. Floresta Way, Menlo Park, Calif.—Civil Engineer with George S. Nolte

ARNOT, John P., 2258 Whitney St., Toledo, Ohio—Chief of Party, T. C. Biebesheimer Engineering Co.

BALL, E. Stuart, 505 Cumberland Ave., Portsmouth, Va.—Partner, Ball and Hassell, Surveyors

BANKS, William L., Jr., Room 2449 Municipal Bldg., New York 7, N. Y.—Jr. Civil Engineer, Dept of Water Supply, Gas and Electricity

BIEBESHEIMER, T. C., 725 Cherry St., Toledo 4, Ohio—Civil Engineer and Surveyor

BOGGUS, Ernest L., 75½ Hunter St., S. W., Atlanta 3, Ga.—Civil Engineer and Land Surveyor

BOLSTAD, Comdr. Roswell, C., 1434 Federal Bldg., Los Angeles 12, Calif.—Hydrographic and Geodetic Engineer, Coast and Geodetic Survey

BONE, Prof. Alexander J., Room 1-349 Massachusetts Institute of Technology, Cambridge 39, Mass. —Associate Professor, Highway and Airport Engineering

BOSWELL, A. W., Box 654, Battleboro, N. C.—Forester-Surveyor, M. C. Braswell Co.

BRADEN, W. E., 108 W. 2nd St., Los Angeles 12, Calif.—Field Engineer, Los Angeles County Engineering Dept.

BRANDT, Orville A., 3867-A N. 18th St., Milwaukee 6, Wis.—Civil Engineer and Surveyor, City of Milwaukee

BREWER, Robert A., 33 Beverly Rd., Berkeley 7, Calif.—Associate Civil Engineer, Division of SFBTC

BROWN, J. Edward, 416 5th St., Virginia Beach, Va.—Land Surveyor

BURNSTINE, Monroe, 522 N. Burdick St., Kalamazoo, Mich.—Chief of Party, DeLeuw, Cather and Co.

CAGE, Conrad, Jr., P.O. Box 787, Monroe, La.—Land Surveyor

CALCANO, Dr. Eduardo, Avenida Negrin 26, Elrecreo, Caracas, Venezuela, S.A.—Director, Cartografia Nacional

CALDERON, Joaquin G., Carrera 14-D, 4-21 Cali, Valle, Colombia, S.A.—Highway Engineer

CHLADEK, Jerome F., 4622 W. Center St., Milwaukee 10, Wis.—Surveyor, Partner, Engel and Engel

CITY ENGINEER, City of Mt. View, Mountain View, Calif.

COPELAND, Alfred, 4458 S. First Place, Arlington, Va.—Civil Engineer and Land Surveyor

CORRY, Richard, Estacada, Ore.

COTTRELL, Jack W., Jamesville Rd., R.D. 2, Manlius, N. Y.—Land Surveyor

CUNNINGHAM, William P., 1923 N St., N.W., Washington 6, D.C.—Cartographer, U. S. Navy Hydrographic Office

DEWART, Alan, 220 Golden Gate Ave., San Francisco 2, Calif.—Asst. Highway Engineer, California Division of Highways

DIEHL, Lloyd G., 4211 Colchester Dr., Kensington, Md.—Land Surveyor, Anchorage Engineers

DIXON, Jack M., Cold Springs Road, Huntingdon, Pa.—The J. Murray Africa Co.

DODL, Rudolph C., P.O. Box 224, Farmville, Va.—Surveying and Civil Engineering

ERSKINE, Mitchell, 152 Mecklenburg St., St. John, N. B., Canada.

EWOLDSEN, Ernst, 963 Grosvenor Place, Oakland 10, Calif.—Surveyor, Alameda County Surveyor's Office

FAIRCHILD, F. M., 2620 Peckham St., Houston 6, Tex.—Instrumentman, Houston Power and Lighting Co.

FASIC, George W., 217 South 7th Ave., West Reading, Pa.—Cartographer, Aero Service Corp.

FEE, Creighton C., Box 162, Faust, N. Y.—Instrumentman, Erdman and Hosley

FINLEY, Dr. Luther E., 2515 N. 36th St., Phoenix, Ariz.—Professor of Technology and Industry, Arizona State College

FLYNN, Robert T., P.O. Box 151, Palisades, Idaho—Construction Management Engineer, U.S.B.R.

FRANCIS, James M., St. Thomas Manor, Linglestown, Pa.—State Research Forester, Dept. of Forests and Waters

GANT, Melvin C., 139 Kendall Way, Covina, Calif.—Survey Party Chief, City of Los Angeles

GIVENS, Alan C., 9739 S.E. Mill St., Portland 16, Oreg.—Chief of Survey Party, Multnomah County Road Dept., Portland Dept.

GOLDSMITH, Hugh, 513 Third Ave., Seattle, Wash. —Manager, Civil Division, Gellert, Griffen, Harrigan & Associates

GREFE, Richard F., Springhill Road, McLean, Va.—Civil Engineer and Surveyor

HALL, Alan E., Route 1, Box 64, Enumclaw, Wash. —Chief of Party, Corps of Engineers, U. S. Army

HASSELL, T. Ray, III, 505 Cumberland Ave., Portsmouth, Va.—Partner, Ball and Hassell, Surveyors

HEFNER, Joe C., Route 3, Box 343, Hickory, N. C.—Surveyor with Walter C. Jones, C.E.

HELLMER, Roy A., P.O. Box 132, Lynn, Mass.—Civil Engineer, Dept. of Public Works, Commonwealth of Massachusetts

HELM, Arnold R., 111 Cold Hill, Granby, Mass.—Owner, Custom Building Service

HIGGINBOTHAM, Paul S., 140 S. Avena Ave., Lodi 4, Calif.—Senior Engineer, Pacific Gas and Electric Co.

HILLIARD, Glenn S., 204 Marvin Rd., Silver Spring, Md.—Surveying, Wilberding Co., Inc.

HOLTBUER, William C., 10940 N.E. Brazee St., Portland 20, Oreg.—Draftsman, Pacific Power and Light Co.

INGALLS, Burton R., Division of Surveys and Maps, Dept. of Public Lands, Box 110, Olympia, Wash.

IZZO, Dominick, 5911 Accomac St., Springfield, Va. —Office and Field Engineer and Land Surveyor, Springfield Surveys

JONES, Delmar R., P.O. Box 1826, Fresno, Calif.—Title Engineer, Title Insurance and Trust Co.

KARN, Bill, 1737 Kraft St., Oceanside, Calif.—Chief of Party for John C. Weeks, Surveyor

KENT, Charles J., Jr., 114 Country Hill Drive, Fairfax, Va.—Land Surveyor, Springfield Surveys

KEPNER, C. E., P.O. Box 2101, San Antonio 6, Tex.—Executive, Edgar Tobin Aerial Surveys

KERNS, Charles J., Gloucester, Va.—Assistant Engineer, Commission of Fisheries

KULIS, Anthony S., 3001 Myer Blvd., McKeesport, Pa.—Photogrammetrist, R. A. Cummings, Jr., and Associates

LEWIS, Glen S., Standard Surveying Co., Box 107, Killeen, Tex.—Land Surveyor

LEWIS, Noy O., P.O. Box 621, Abbeyville, La.—Land Surveyor

LURAGHI, R., Vice President, Filotecnica Salmoiraghi, Inc., 41-14 24th St., Long Island City 1, N. Y.—Instrument manufacturers

MARTIN, John W., 1212 18th St., N.W., Washington 6, D. C.—Supervisor, Photogrammetric Unit, Airways Mapping Service, Inc.

MAYER, Richard R., 3767 Darrow Rd., Stow, Ohio—Surveyor with S. G. Swigart and Son

McCLELLAN, John Howard, Trust Company Bldg., Waynesboro, Pa.—Land Surveyor

McCONNELL, H. J., P.O. Box 4197 (T&C), Sacramento 21, Calif.

McGEORGE, Darrell R., U.S.S. *Tanner* (AGS-15), c/o Fleet Post Office, New York, N. Y.—Surveyor, U. S. Navy Hydrographic Office

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Trainee Program

The following, quoted from a release by the National Bureau of Standards, seems to us to suggest one possible answer to the question, "Where are the future land surveyors to come from?" The National Bureau of Standards has apparently been quite successful in interesting capable students in the program and in eventually securing their services on a permanent basis. It seems possible that surveying organizations might well give some thought to a similar method of interesting students in the profession of land surveying. —EDITOR

"In an effort to meet its increasing demand for high-caliber technical graduates, the National Bureau of Standards is giving students an opportunity to become acquainted with a government research laboratory during their undergraduate summers, and discover the advantages of a professional career at the Bureau. Open to physical science and engineering majors and also to selected high school graduates who have displayed unusual scientific ability, the Student Trainee Program is proving mutually beneficial to the Bureau and the trainees. Approximately 150 students have been employed annually since the program was initiated in 1948. Besides carrying their share of the work load during the summer, many fulfill the ultimate aim of the program and later return to the staff in a permanent capacity."

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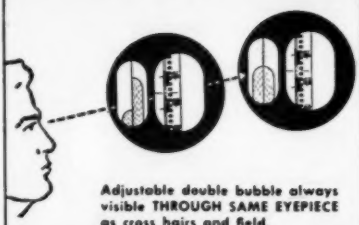

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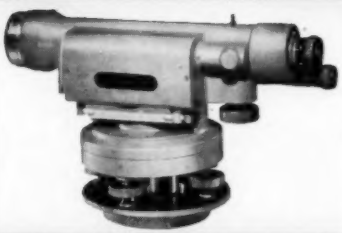

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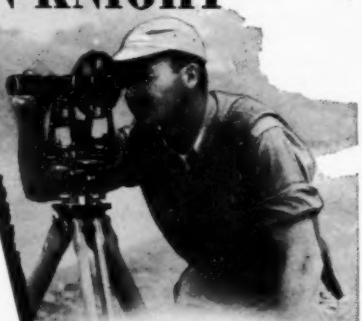

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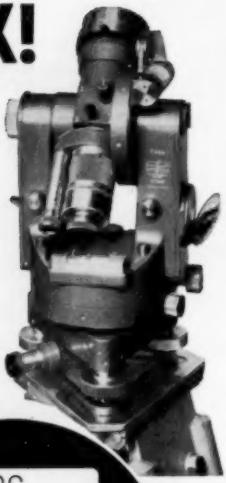

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FROM THE MAILBAG

July 31, 1956

Dear Mr. Evans:

I thank you very much for your letter of July 23, with which were enclosed my membership card and two very provocative cartoons.

Please receive my compliments for your very cordial letters, that always have a touch of deep humor and intellectual finesse.

With pleasure I always recall my recent visit to Washington during the 1955 ASP–ACSM Consecutive Meetings, and how nice everybody was to me.

I am busy indeed, and in good health.

If I may suggest, it will be very useful to encourage mutual correspondence among ACSM members, although most surveyors are people without extra time left during their lifetime. You know the clients; they always want the maps yesterday!

Well, for the time being—all the best and regards to Mr. Dix. I hope he remembers me.

Yours sincerely,
N. Leef
(Nimrod Leef)

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Executive Secretary Dix, in forwarding the above to your editor, made the following comments:

"The Institute was founded by the late Zalman Leef."

"The glow of friendly cordiality has lasting warmth as witnessed in the above tribute to our beloved Treasurer's outstanding personality."

"Correspondence between members of ACSM located in different parts of the world makes for good international relations."

"The surveyor-client relationships are the same the world over—it seems."

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FENN COLLEGE ENROLLMENT

Substantial enrollment gains were recorded by Fenn College this fall in both day and evening divisions. Engineering students account for 60% of the entering class and increase the college's total engineering registration to 700, an increase of 20% over last year. The engineering school, the only one in the Greater Cleveland area offering full degree programs at night, registered 904 part-time students, a gain of 4% over the previous year. ACSM member G. Brooks Earnest is President of Fenn College.

Foreign Maps

The problem of procuring authoritative maps of foreign areas is one for which there is no easy solution. Fortunately, however, there are now available several lists of foreign maps and map publishers. One such list, compiled by William Hannah, was printed in SURVEYING AND MAPPING, April–June 1956, Vol. XVI, No. 2, pages 212–216.* A more comprehensive international list of maps and publishers, the *Bibliographie Cartographique Internationale*, was described in a brief note in SURVEYING AND MAPPING, July–September 1956, Vol. XVI, No. 3, page 395.*

In July 1956, Edward Stanford Ltd., 12–14 Long Acre, London W.C. 2, England, issued *A List of Maps Published by Many Official Foreign and Colonial Surveys.* It includes descriptions and prices of map publications for some 50 countries and dependencies.

WALTER W. RISTOW

Library of Congress

* An extension of this list appears in the "Map Information" department of this issue of SURVEYING AND MAPPING.

A True Story

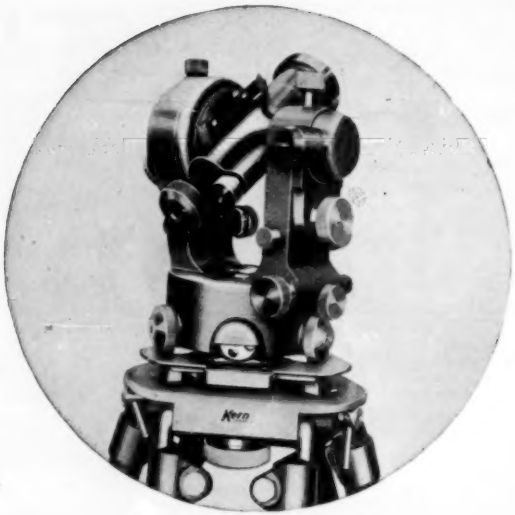
EDITOR'S NOTE:—The story which follows appeared under the above title in the August 1956 issue of *Field Notes*, the monthly publication of the Georgia Association of Registered Land Surveyors (GARLS).

Triangulation station MERRIWETHER was lost. A bulldozer made it a casualty along with both its reference marks. It was like some land corners that need to have added permanent stakes a tape length or less away on the line. Then there came a forward-looking GARL who had connected land corners to MERRIWETHER with true azimuths and accurate distances, closure checked. From one of these land corners he observed the sun, retraced his traverse, and there in a small deep hole found the undisturbed undergound mark. MERRIWETHER was found again. The Old Marksetter is truly grateful for this and all the many similar instances and for all those who are watching other MERRIWETHERS. That GARL proved to be a real professional, a real GARL. He knows that from MERRIWETHER he can restore the land corner, if ever (and may it be never) that need arises.

Mount McKinley Taller

A newly accepted elevation for the summit of Mount McKinley in Alaska was announced last August by the National Geographic Society. The new altitude, 23,320 feet, is based on ten years of surveys sponsored by the Society and under the leadership of Dr. Bradford Washburn. The previously accepted figure was 23,300 feet. It is reported that the new value for the elevation of the tallest mountain on the North American Continent will be accepted by both the Geological Survey and the Coast and Geodetic Survey.

Mount McKinley is probably the tallest mountain in the world in one respect, in that it rises to a height of over 23,000 feet from a plateau which is only 2,500 to 3,000 feet high.



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National Standard of Length Returns to U. S.

The national standard meter bar, basis of all length measurements in this country, has been safely returned to its vault at the National Bureau of Standards after comparison with the international standard in France, according to an announcement by Dr. Allen V. Astin, Director of the National Bureau of Standards.

The extremely precise measurements required for accurate comparison of the two meter bars were carried out at the International Bureau of Weights and Measure at Sèvres, a suburb of Paris. Because of the great value of the standard meter bar to science and the difficulty of replacing it, Dr. Lewis V. Judson, Chief of the Length Section, personally carried it on its journey in a specially constructed case. The U. S. meter bar remained at Sèvres about two months.

Although the final report on the Sèvres measurements had not been received by the middle of September 1956, NBS has been informed that it is now certain the U. S. standard meter bar has not changed since it was first received from the International Bureau in 1890, during the term of office of President Benjamin Harrison.

Dr. Astin said, "This is only the third time in more than 65 years that we have sent our national length standard abroad for comparison with the international standard. It is most gratifying to learn that there has been no discernible change in the relative length of these two standards throughout that period. Were the length of our standard meter to undergo appreciable change, even though very gradually, confusion would ultimately result, not only in everyday buying and selling but in the mass production of interchangeable parts and in most fields of scientific and engineering work."

The national standard meter bar is made of an alloy of platinum (90%) and iridium (10%). The platinum-iridium alloy was chosen because of its hardness and long-range stability. The meter is defined as the distance between two parallel lines on the bar at the temperature of melting ice.

The value of the alloy contained in the meter bar is about $10,000, but its actual value is, of course, much greater. Because it is the actual standard and practically irreplaceable, its true value can scarcely be estimated.

The standard meter bar is ordinarily kept locked in a vault on the grounds at the National Bureau of Standards. At infrequent intervals is it removed for checking other standards. The vault was recently equipped with a glass door so that visitors can be shown the standard meter bar and standard kilogram without removing them from the vault.

Our National Standard Prototype Meter is one of 30 meter bars made as nearly identical as possible, under the supervision of an international committee, and completed in 1889. Number 6 of this series was designated the International Prototype Meter to serve as the standard of length for the world, and this country was allocated number 27 to serve as our national standard. Prototype number 21 was also allocated to the United States and is used as a secondary standard.

The U. S. standard meter bar was previously taken to the International Bureau of Weights and Measures in 1903 and again in 1922–23 for comparison with the international meter bar. Final results of the measurements in each case showed no change in length.

In the vault at NBS, along with the standard meter, is also kept the national standard of mass, U. S. Prototype Kilogram No. 20. This standard is also a copy of a standard kept at the International Bureau of Weights and Measures. Together with the standard meter, it serves as the basis for all weights and measures in American commerce, industry, and science.

While the yard and the pound are the customary units in everyday transactions, these units are actually defined in terms of the standard meter and standard kilogram. For example, 1 yard equals 0.914402 meter. Thus, indirectly the standard meter determines the length of a yard of cloth. Likewise, and of more interest to readers of this magazine, the standard meter determines the length of all our tapes used for surveying.

The International Bureau of Weights and Measures is located in international territory at Sèvres. Here the international standard meter bar and standard kilogram are kept in a vault, deep under the ground, where they lay undisturbed through two world wars. The International Bureau was established in 1875 by a treaty signed by 17 nations, including the United States. The very accurate copies of the international standard meter and standard kilogram were given to the nations that signed the treaty.

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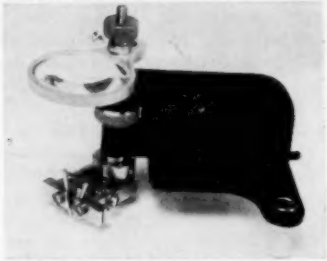

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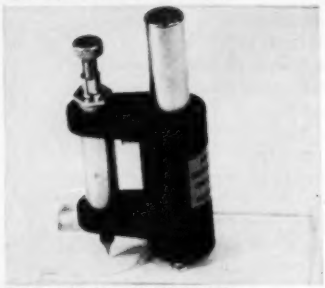

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Commemorative Stamp for Surveyors

NOTICE to ACSM members, Sections, Divisions, and affiliated groups.

Now is the time for concerted action in support of the issuance of a United States Postage Stamp to honor the professional surveyor. All of you with an interest in surveying, by individual letters, group petitions, and group resolutions, are urged to request the Postmaster General directly, and indirectly through your Congressmen, to issue a Commemorative Stamp for Surveyors in time for "first day" ceremonies on Surveyors' Day, August 23, 1957, at the College of William and Mary in Virginia, Williamsburg, Va.

The Postmaster General has been given discretion in the selection of a limited number of commemorative issues to be produced in any one year. Due to the tremendous number of requests, the difficulty of choosing among them, and in the effort to follow orderly procedure, Congressional committees are reluctant to force the issue by acts but give earnest support by letter to the Postmaster General if urged by their constituents.

ACSM has been advised as follows: "The primary effort, therefore, should be for the professional societies of surveyors, and other groups interested, and individuals, to make known to the Postmaster General the extent of support for the proposed stamp." A secondary effort is to let your U. S. Representative and U. S. Senator know your views and urge their support by their writing to the Postmaster General or otherwise calling the matter to his attention.

With Texas* and Virginia already setting the pace and with Surveyors' Day on August 23, 1957, in conjunction with the celebration of the 350th anniversary of the settlement at Jamestown, the opportune "trigger" for action on the "commemorative stamp" matter, everyone should get behind this drive and write and act in full support to have the honoring stamp issued.

Write the Postmaster General, Post Office Department; your Senator at the Senate Office Building; your Representative at the House Office Building; your Representative at the House Office Building—all at Washington 25, D. C.

To the President of the College of William and Mary in Virginia, a resolution:

WHEREAS, by the Charter of 1693 the College of William and Mary in Virginia was made Surveyor-General of Virginia and the faculty of the College entrusted with the duty of examining surveyors and of granting them licenses; and

WHEREAS, George Washington in 1749, at the age of seventeen, was licensed a surveyor by the College of William and Mary; and

WHEREAS, he was a professional surveyor until other duties demanded his time; and

WHEREAS, he was Chancellor of the College of William and Mary from 1788 to 1799, when he died; and

WHEREAS, a number of the faculty of the College were members of colonial survey commissions;

BE IT RESOLVED, that the American Congress on Surveying and Mapping request the President of the College of William and Mary in Virginia to petition the Virginia members of the Congress of the United States to ask the Postmaster General to have a stamp issued in accordance with the attached design,** at Williamsburg, Virginia, on the occasion of Surveyors' Day at the College of William and Mary on August 23rd, 1957.

This certifies that the above resolution is a true copy of the resolution adopted at Executive Committee Meeting for the Board of ACSM on October 2, 1956, in Washington, D. C.

For AMERICAN CONGRESS ON SURVEYING AND MAPPING

[SEAL]
October 2, 1956

WALTER S. DIX
Executive Secretary

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* *See* "Report on the Commemorative Stamp for Surveyors," SURVEYING AND MAPPING, July–September 1956, Vol. XVI, No. 3, page 402.

** Because no copy of the design available to the Editor was suitable for reproduction, the suggested design for the stamp cannot be shown. —EDITOR

1956 Annual Convention American Society of Civil Engineers

This year, the Annual Convention of the American Society of Civil Engineers was held at the Penn-Sheraton Hotel, Pittsburgh, Pa., during the week of October 15th. Ordinarily, this convention meets in New York, but occasionally, once in four or five years, another city is selected.

The Surveying and Mapping Division of the Society held its Technical Session on the morning of Thursday, October 18th. The meeting was presided over by B. E. Beavin, Sr., Chairman of the Executive Committee of the Division. Approximately 75 attended.

Professor George H. Harding, recently returned from the Philippine Island where he was engaged as a consulting engineer on land surveys and now a consulting engineer in Columbus, Ohio, emphasized the great need of additional surveys and maps in the Philippine Islands, to supply basic data so necessary in the development of the natural resources. In particular, he brought out the lack of geodetic control in the interior portions of the various islands. Much work has been accomplished along the coastal areas for control of hydrographic surveys, but this work should be extended inland to furnish a basis for future mapping and for land surveys.

The second paper was given by William O. Baker, Chief Photogrammetric Engineer, Michael Baker, Jr., Inc., Rochester, Pa. Mr. Baker's paper covered the entire field of the application of photogrammetry to civil engineering projects.

The third paper, given by Robert A. Cummings, Jr., Partner, Robert A. Cummings Jr., and Associates, Pittsburgh, Pa., dealt with the subject of aerial triangulation by photogrammetric methods and its importance in reducing field work. This subject is of particular interest at this time, chiefly because of the scarcity of engineers.

The last paper was concerned with the survey program on the St. Lawrence River and was ably presented by W. H. Williams, Chief Surveyor, The Hydro Electric Power Commission of Ontario, Toronto, Canada. Mr. Williams explained the complexities of this extensive survey program and brought out, as an aside, the desirability of the establishment of plane-coordinate systems in Canada, similar to our State coordinate systems in the United States.

During the afternoon of October 18th, the Annual Meeting of the Executive Committee, Surveying and Mapping Division, was held as an "open" meeting in which all interested engineers were invited to join.

The agenda for this meeting included reports of the various Technical Committees of the Division and other subjects of current interest.

One of the most interesting reports was that of the Task Committee on the Status of Surveying and Mapping. This committee comprises Brother B. Austin Barry, Chairman, Professor, School of Engineering, Manhattan College, New York; George D. Whitmore, of the Geological Survey; and Alfred O. Quinn, Aero Service, Inc., Philadelphia. Because Brother Barry was delivering a paper at an engineering meeting in Florida, Mr. Whitmore reported on the activities of the Task Committee.

At the Annual Meeting in 1955, the initial report of this Task Committee was presented as "Phase One." This report, in brief, defined which categories in surveying and mapping were professional and which were at the technician or preprofessional level.

The interim report of this year tentatively defines which categories of surveying and mapping should be considered as engineering and which as non-engineering. This general subject has been quite controversial in the last several years and it is hoped that the final report of the Task Committee will represent a definitive and acceptable statement on the Status of Surveying and Mapping.

The open session of the Executive Committee was attended by all members as well as a sizable group of other interested engineers. The final action taken was the transfer of the Chairmanship of the Executive Committee, Surveying and Mapping Division, from B. E. Beavin, Sr., of Baltimore, Md., to Professor Oscar C. J. Marshall of Toronto, Canada.

VERTICAL FILE FOR MAPS AND PLANS

The manufacturers of the "Plan Hold" line of vertical filing equipment have a new eight-page catalog: "The Plan Hold Story" showing four different methods of vertically filing blue prints, maps, etc.

Included in this Catalog (No. 5) is the Type "S" Standard Plan Hold which can be used in various homemade racks in place of sticks, slats, etc. Holes and other mutilations are eliminated with the Plan Hold friction-type binders, which are made of aluminum and will hold from 1 to 150 sheets.

A copy of this new catalogue may be obtained on request to Plan Hold, 5204 Chakemco St., South Gate, Calif.

HUNTING TECHNICAL SERVICES, INC.

As of October 1, 1956, Hunting Technical Services, Inc., 57 Park Ave., New York 16, N. Y., will act as the representatives in the United States of Hunting Aerosurveys Ltd., Hunting Geophysics Ltd., The Photographic Survey Corporation Ltd., Aeromagnetic Surveys, Ltd., and the companies of the Hunting Group of Aerial Survey Companies. This group of companies has been operating in England, South America, Africa, Australia, New Zealand, and Canada. An interesting brochure, "Ninety-two million more mouths to feed," has been issued by Hunting Technical Services, Ltd., London, and is presumably obtainable from the new office in New York.

TIPS FROM THE SURVEYOR'S NOTEBOOK

"Tips from the Surveyor's Notebook" is a new collection of short articles on unusual surveying problems and their solutions which has been published by W. & L. E. Gurley.

This 20-page "Notebook" contains the articles, case histories, and field tips which have created most comment and have proved most useful to engineers and surveyors during the six years the "Notebook" has been published. The new phamphlet contains selected pages from Series One and Two.

Copies of this publication may be obtained from Gurley dealers or by writing W. & L. E. Gurley, Troy, N. Y.

It is interesting to note that six of the "tips" included in this collection came from ACSM members—S. E. Huey, Monroe, La.; G. W. Herzog, Houston, Tex.; Gordon E. Ainsworth, South Deerfield, Mass.; John Goggin, Marathon, Fla.; Gerald Hyde, Nashua, N. H.; and Stanley M. Shartle, Indianapolis, Ind.

BIG CAMERA

A contract for the largest camera ever built on the West Coast has been awarded to Gordon Enterprises by the U. S. Air Force. This giant camera, measuring 25 feet in length and weighing five tons, will utilize a 30-inch lens. It is being manufactured for the Air Force Flight Test Center at Edwards Air Force Base, Calif.

The easel of the camera will have 50 automatic magnets to hold the drawings and documents while they are being photographed. Other features of the big camera include motor drive for the easel, controllable either from the easel or from the camera body. The entire bed of the camera will be shock-mounted to eliminate any possibility of vibration during exposure.

AERIAL PHOTOGRAPHY OF THE UNITED STATES

The U. S. Geological Survey has issued the Eighth Edition of the map showing "Status of Aerial Photography." This map bears the date "June 1956" and shows all areas known to have been photographed by or for Federal, State, and commercial agencies. The color pattern of the red overprint on the base map, which is at the scale of 1: 5,000,000, shows for all the areas the agency holding the primary photography. Copies of this map are available on request to the U. S. Geological Survey.

A casual inspection of the map shows that very little of the United States has not been photographed by some one of the various agencies carrying on aerial photographic work.

INSECT REPELLANT

Convenient and effective protection against mosquitoes, flies, gnats, chiggers, and other bothersome insects is offered by Repellen-Tissue, a new product which resembles cleansing tissue and is offered in plastic pouches containing 10 tissues. These tissues may be used to wipe away perspiration and to apply the insect repellent at the same time. The claim is made that these tissues contain no grease, are convenient to use, and may be used a number of times. Designed for use by road crews, linemen, telephone repairmen, pipeline workers, and others who must remain outdoors for long periods, these tissues could possibly be useful to *surveyors* under certain conditions.

For further information write to Mine Safety Appliances Company, 201 N. Braddock Ave., Pittsburgh 8, Pa., and ask for Bulletin No. 0408-12.

PROGRAM PREVIEW—the coming March annual meetings

1957 ASP—ACSM Consecutive Meetings and Co-Exhibit

March 3–9, 1957, Shoreham Hotel, Washington, D. C.

Sessions of American Society of Photogrammetry—
Monday, Tuesday, Wednesday morning

Sessions of American Congress on Surveying and Mapping—
Wednesday afternoon, Thursday, Friday

ASP PROGRAM: The technical program of the American Society of Photogrammetry is being designed to the diversified interests of its many members. There will be technical papers on many phases of photogrammetric activity. The committee on programming plans to present feature items on current photogrammetric developments including high altitude photography which concerns the taking of aerial photographs from 90,000 feet above the surface of the earth. There also will be papers on instrument development and application of interest to problems of aerial photography in general. Photogeology papers are scheduled of interest to the application of modern photogrammetric approaches to geologic mapping or geologic studies and the role of photogeology in geologic exploration. Of partiuclar interest to users of aerial or terrestrial photographs are important papers on the subject of photointerpretation, which, to those not versed in photogrammetry, is the accurate image object identification phase of photogrammetry rather than the measuring of height or distance between object points by stereoplotting means. Photointerpretation of length of object shadows, and the various shadings in the image picture, can also very often determine time or distance approximations. Surveyors and engineers need not be photogrammetrists to understand and enjoy this interesting subject area. An all-important attraction will be a feature panel on the role of photogrammetry in the coming Federal Highway Program.

KEY SPEAKER: The speaker for the mid-convention general assembly will be the President of the International Society of Photogrammetry, Major General R. Llewellyn Brown, C.B., C.B.E., of England, an internationally known geodesist and well known to many members of ASP and ACSM by long association as the Director of Surveys in British mapping circles.

ACSM PROGRAM: The six Divisions of ACSM will present programs in the general plenary and divisional sessions, to reflect the broad objectives of the American Congress on Surveying and Mapping in the public interest and in the technical and professional scope of its membership. **Cartography:** plans continuation of its exploratory workshop in which representatives of major commercial and governmental cartographic agencies will inventory existing practices of producing small amounts to tens of millions of maps and charts annually for better understanding of problems of estimating, manpower, and production control; including philosophies of central control versus delegated unit responsibility, and analysis possibilities by electronic digital computers. **Control Surveys:** programs the important part control surveys play in the President's new roads program; the possible future relief from aching backs—or the potential of the Tellurometer in control surveys; and a resume and review of the new Federal specifications for horizontal and vertical control. An interesting report on the evaluated public worth of control surveys may also be presented. **Education:** plans an interesting and important panel discussion on the topic of electronic computers, and also schedules a joint panel with ACSM's Property Surveys Division in discussing the mutual problems related to education of the land surveyor. **Instruments:** plans to feature the usage and field results of the new South African-developed Tellurometer, a wavelength device for measuring distance. Also programed is a panel of surveying and engineering equipment manufacturing experts to answer questions polled by national questionnaire on the subject—"Are you satisfied with presently available surveying equipment, and is it adequate to perform accurately and efficiently the precise layout work required today?" **Property Surveys:** features the annual "town meeting" on land-surveying matters of current interest—registration and license, examination and qualification, professional status, interstate commerce and labor law interpretations, insurances, boundary and title problems, etc. Matters mutually relating to educating the land surveyor will be discussed in joint-panel session with the ACSM Education Division. A paper on survey computations is scheduled, and survey activities on the DEW line project, the Distant Early Warning radar chain in the Arctic, will be related by a Canadian Member of Parliament. **Topography:** presents a nontechnical discussion on "Mapping for the Federal Highway Program" of particular interest to contract mappers. Also programed is "Mapping the Alaskan Range" covering field control and problems in relation to convergent aerial photography on the project, related by those closely in charge of the operations. Other items of topographic interest will appear in the Division's technical-business session. **All six Divisions:** of course, will have business sessions during the convention.

CO-EXHIBIT: The ASP-ACSM Exhibit enjoys national ranking as top show in its field, and this year's exposition has every indication of again being outstanding and a main attraction to many visiting the convention.

SOCIAL FUNCTIONS: ASP-ACSM social co-activities will feature the traditional cocktail socials, the grand banquet with entertainment, the dance, and a program for the ladies.

PLAN YOUR RESERVATION NOW

GLENN C. WELDEN, *Deputy for Publicity*
1957 ASP-ACSM Consecutive
Meetings and Co-Exhibit

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SURVEYING AND MAPPING

Volumes XIV and XV

Cumulative Index

SURVEYING AND MAPPING

Volumes XIV and XV

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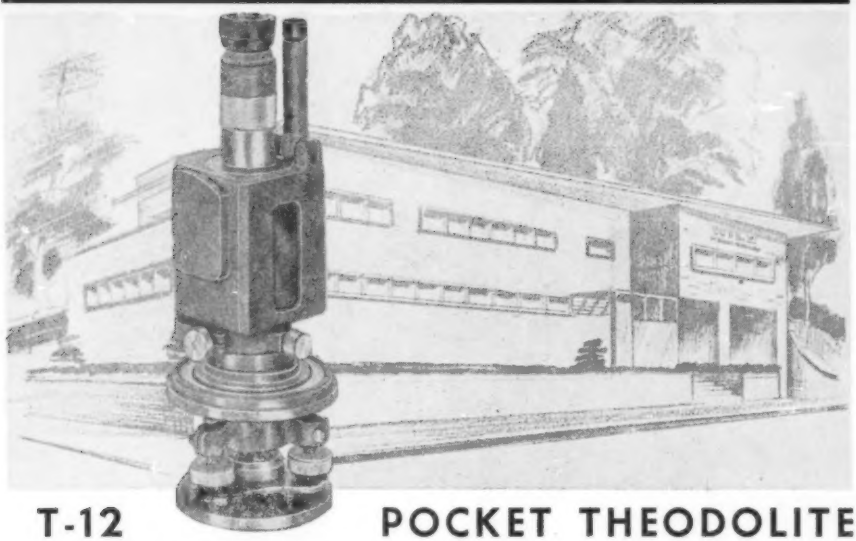

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